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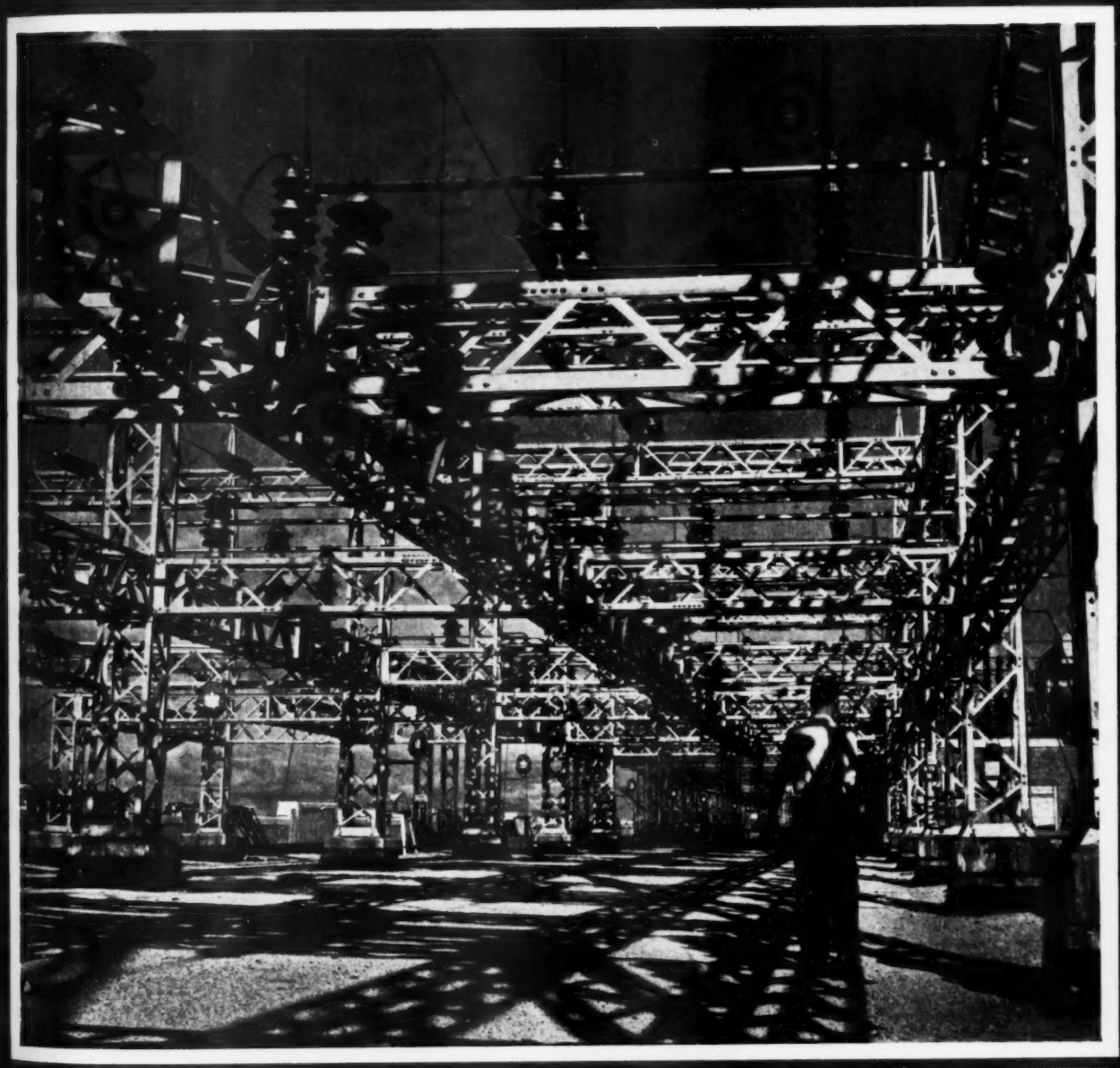

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Contents

203 Lines of development

204 Education outside the universities

205 Electrical engineering in Canada
by Prof. A. PORTER, M.SC., PH.D., MEMBER

209 Trials and tribulations of a service engineer
by J. RUSSELL TAYLOR, T.D., B.SC., M.I.MECH.E., MEMBER

212 Electricity and electronics in aviation
by The Rt. Hon. The VISCOUNT CALDECOTE, D.S.C., M.A., ASSOCIATE MEMBER

215 Britain's fuel reserves
by Sir HAROLD HARTLEY, G.C.V.O., C.B.E., M.C., M.A., F.R.S., HONORARY MEMBER

218 Annual Dinner of The Institution, 1961

224 Letters to the Editor

226 Transistors and all that

228 Institution Council meeting on the 2nd March 1961

The Journal digest:

229 Papers read (*see next column*)
235 Papers published (*see next column*)
236 Monographs (*see next column*)
237 Papers to be read (*see next column*)
238 In the *Proceedings*

239 Obituary

241 Some recent books

248 Technical publications

249 Library accessions

250 Forthcoming events at Savoy Place

250 District Meeting

251 Elections and transfers

252 British Nuclear Energy Conference

253 Announcements to members

256 London report

258 Bulletin of the Sections

262 News from the Centres

265 Officers of The Institution

lxii Index of advertisers

229 Papers read

Silicon power rectifiers	A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams
Protection of h.v. insulators	A. E. Guile
A.C. crane-hoist control	O. I. Butler and V. Ahmad
Vacuum as an insulator	R. Hawley

235 Papers published

Rural electrification	G. F. Peirson
Propagation of 3cm radio waves	F. A. Kitchen, W. R. R. Joy and E. G. Richards

236 Monographs

Waveguide junction containing dielectric	P. J. B. Clarricoats
Dynamo-electric-machine field-problems	K. G. Mukherji
Linear multivariable filters	R. J. Kavanagh
Electric arc in transient conditions	I. A. Black
Linear accelerator using a helix structure	D. P. R. Petrie, R. Bailey, D. G. Keith-Walker, H. Longley and D. R. Chick

237 Papers to be read

Circuits for the banana-tube colour-television display system	K. G. Freeman
Mechanical and manufacturing aspects of the banana-tube colour-television display system	H. Howden
Appraisal of the banana-tube colour-television display system	K. G. Freeman and B. R. Overton
The banana-tube display system: a new approach to the display of colour-television pictures	P. Schagen
Colorimetry of the banana-tube colour-television display system	R. N. Jackson
Development of the banana tube	B. A. Eastwell and P. Schagen
Voltage stabilization by corona discharge	E. Cohen and R. O. Jenkins
Impedance/frequency characteristics of glow-discharge reference tubes	F. A. Benson and P. M. Chalmers

ELECTRICAL ENGINEERING IN CANADA

THE increase in installed generating capacity in Canada in 1960 was approximately 2600 MW, compared with an average annual increase in the United Kingdom during the past few years of about 1800 MW. Prof. A. Porter gives these figures in his article 'Electrical engineering in Canada' on p. 205.

This month's cover illustration shows the insulators and busbars, part of a 220 kV network, on the roof of the power station at Beauharnois in the Province of Quebec. Energy transmission is one aspect of electrical engineering discussed by Prof. Porter

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 7 NUMBER 76 APRIL 1961

LINES OF DEVELOPMENT

THE British Television Advisory Committee's report has now been issued for some 11 months, and in this period its contents have been eagerly discussed by the whole of Britain's radio and electronics industry. The implications of the report are still to be discovered, for indeed, although it does make certain recommendations for the future of British television, it does not—perhaps conveniently—concern itself with any mandatory decisions.

Further time has still to pass before this country will know how television is to develop, and it will be one of the tasks of the recently formed Committee on Broadcasting to make further recommendations concerning the implementation of the report. It will then fall to the Postmaster General to decide whether to accept the committee's findings in full or in part, and the future plan should then be clear. At the moment, then, it seems apparent that very little change can be expected in British television during the next two years.

It is not proposed in this Foreword to comment on the recommendations which the T.A.C. report has made, but rather it is the intention to look ahead to anticipate the situation when the recommendations are implemented. The T.A.C. report could have many significant effects on the electrical and electronic engineering industries of this country, and these are worthy of examination.

Any future change in the television system will certainly be based on the somewhat conflicting economic, social and technical aspects, and it is the recognition of this that has led to the formation of the predominantly non-technical Pilkington Committee. The situation has been reached where television can no longer be considered solely on the merits of the electronic system which it is proposed to use. Assuming, from an engineering viewpoint, that the system which is eventually introduced has already been proved to be technically feasible, the social and economic implications of its introduction will be largely independent of the features of the system itself.

Following this line of thought (and assuming that no major technical planning errors are made), it becomes clear that whatever system is chosen—whether it be 625 lines or 1000 lines, positive or negative modulation, a.m. or f.m. sound—the result in the end will be the same. For whatever the contents of the black boxes, the final television service will be entirely dependent on the degree of national and commercial investment and support it can command. Without this investment there can be no new services, and it is this guaranteeing of financial stability, in relation both to programme considerations and to the receiver industry, that has become so important in all future television planning.

The comment has been made that decisions resulting from the T.A.C. report are what the industry has been waiting for—the go-ahead signal. In the past year the radio- and television-receiver industry has not found such a ready market for its products, and the new plans for television are now eagerly awaited. A heavy swing back to the large production of domestic receivers may occur in the electronics industry, away from the present emphasis on military-defence projects, and at such a stage a prosperous industry can be anticipated.

On the capital-equipment side, the new demands for transmitters, cameras and complete studio equipment are likely to keep the manufacturers fully occupied, and possibly there will be an initial shortage. The transmitting authorities will also have to seek financial approval for their own expansion programmes.

The introduction of a new service would mean a major technical upheaval, and some new thinking would be required from both the transmitting authorities and the receiver industry. A reorientation of ideas from a familiar 405 line system would not be achieved overnight. A relatively simple change, say to 625 lines, would involve some initial confusion, but a more complicated

change, say to colour television, would be a larger problem.

One of the first sections of the industry to find themselves fully extended would be the dealers and servicemen. The situation might be reached where graduates would be required in the servicing industry as the complexity of domestic television equipment increased. Although some excellent training schemes have been undertaken by dealers, it is still rare to find a servicing engineer who is not a little vague in his understanding of the fundamentals of electronic circuits. Although this has not been important in the past, it would assume a new relevance when a new system was first encountered. Not that there is anything basically different in 625 line and 405 line television; the question rather would be whether the *past* technical training of the people concerned had been sufficient for any new outlook to be adopted.

From this we can deduce that training schemes should be started now, covering subjects such as u.h.f. propagation techniques and the details of 625 line and colour systems. Some financial assistance to the servicing industry might have to be provided by the receiver manufacturers in order to make sure that the necessary test-gear was available when the time arrived.

The effects of a new television system on the British receiver industry would also be considerable. Assuming that the system would be basically similar to that used in Europe, British manufacturers would have to ensure that supplies of 625 line receivers were immediately available, or imported equipment might swamp the market. For the first time, the British receiver industry would have to meet foreign competition, and this competition might be strong. The Continental manufacturers would have had the advantage of several years' mass-production experience in their own home markets. The argument that it would also work the other way—i.e. that Britain would be able to export 625 line receivers—might not be valid, for few manufacturers have been significantly successful in persuading the Continent to buy British radio receivers.

As far as the ultimate technical goal—colour television—is concerned, the report is significantly silent and no specific recommendations are made for the future. Colour television would be the greatest shot in the arm for the industry since black and white television was started again after the recent war. In many ways it would be a challenge to succeed which could stimulate the industry. Our inherited 405 line system—although it is providing, and has provided, an excellent service—has not stood us in good stead oversea. Its retention has been something of a mystery to foreigners and at times an embarrassment to ourselves.

But this situation could easily change, for, armed with the best refinements in a 625 line system backed by a colour service, British television could regain its world prestige. The full significance of the eventual introduction of colour would probably be realized only after the event. Colour could be introduced too soon, in which case the service provided would be unsatisfactory.

On the other hand, there could be an equal danger of waiting too long—waiting for the perfect system, waiting for the perfect colour-display tube. Already, the N.T.S.C. and SECAM systems are known to be capable of producing satisfactory colour signals, but developments in colour receivers are still awaited. There is also the problem of the cost of the receiver. The situation is indeed similar to that which existed when high-definition 405 line television first started in Britain, when the receiver-picture quality did less than full justice to the system.

The responsibility resting on the Committee on Broadcasting and the various industrial technical committees is great; the future progress of British television is now to depend on some bold technical and economic plans that will stand the test of time. That this progress will be watched oversea, probably as closely as our political activities, indicates the magnitude and significance of the issues at stake.

EDUCATION OUTSIDE THE UNIVERSITIES

The Minister of Education, Sir David Eccles, stated recently that in all the British universities taken together there were 100000 people studying for a degree, while outside there were nearly the same number of students taking courses beyond the General Certificate of Education Advanced level. The Minister explained that 30000 people were studying in the evening, 40000 in part-time day courses and 24000 in full-time and sandwich courses.

The technological departments of the universities had 15000 places, while in the colleges of advanced technology there were already between 8000 and 9000 people studying for diplomas in technology, i.e. over half the university score in numbers.

Sir David considered that every year industry appreciated more keenly that the colleges of advanced technology were the nurseries of the men who would develop the scientists' inventions and would remove from Britain the complaint that her best brains were brilliant in pure theory but were unable to turn their thinking to practical account with the same brilliance.

A vigorous economy and a healthy society required many other professional qualifications besides those of the engineer and the scientist. The business manager, salesman, statistician and market researcher were but a few of those essential for an efficient organization. The colleges of advanced technology were increasingly catering for these other careers.

621.311.1: 621.391 ELECTRICAL ENGINEERING IN CANADA

This brief account of developments in electrical engineering in Canada makes special reference to generation, education and research, in which fields considerable advances have been made during the past few years. The author was formerly Professor of Light Electrical Engineering, Imperial College of Science and Technology, University of London, and is now Dean of Engineering, University of Saskatchewan. He becomes Professor of Industrial Engineering at the University of Toronto on the 1st July 1961.

Prof. A. PORTER, M.SC., PH.D., MEMBER

IT may not be well known that the increase in electrical generating capacity in Canada in 1960 is likely to prove greater than that in the United Kingdom. Thus, in 1960 the increase in the installed generating capability will be approximately 2600 MW, while the average annual increase in the United Kingdom during the past few years has been in the order of 1800 MW.

Furthermore, in some provinces, notably British Columbia, Alberta and Saskatchewan, the net generating capability during the past decade has been increased threefold. For the country as a whole, the net capability has increased from 9000 MW in 1950 to 22000 MW in 1960. It is not surprising that the gross value of electrical manufacturing has, during the same decade, increased by a factor of ten. Moreover, during this same period there has been an equally spectacular increase in the number of electrical engineers graduating from Canadian universities.

Transmission-line tower looking down on the Upper Kemano Valley, British Columbia

The generation of electric power

With few exceptions, all Canadian provinces are well endowed with hydroelectric-power potential. In the Province of Quebec, for example, hydroelectric power accounts for 98% of the total generated—this amounts to nearly 9000 MW. In areas where the hydroelectric potential is limited, there is a plentiful supply of coal, oil and natural gas (examples are the Provinces of Saskatchewan and Alberta, although in the former there is an increasing possibility of utilizing hydroelectric power).

In the Province of Ontario, the proportion of thermal generation (using both coal and oil fuels) is increasing rapidly because hydroelectric resources have been fully exploited, and it is not unlikely that within the next ten years at least one or two nuclear-power stations will be added as base-load stations.

In the Province of British Columbia there is an abundance of electric-power potential because of the nature of the country and climate. It is estimated that the Columbia River and the Peace River alone are each capable of providing about 34 million horse-power of electric power. And, in addition, British Columbia has massive natural-gas and coal reserves.

The position in two other provinces is similar, although the rapidly increasing industrialization of eastern Canada will call for at least a 100% increase in electric-power generation during the next eight years, and power may have to be transported from remote areas of Canada to the populated regions.

Many parts of Canada are sparsely populated, and the problem of providing comparatively cheap electric power has always been difficult. But it is interesting to note that, in spite of an increase of 30% in the cost-of-living index during the past decade, the cost of power production has shown a steady decrease. Indeed, in the Province of Saskatchewan there has been a 28% reduction

in generation cost per kilowatt-hour and a corresponding 10% increase in transmission cost since 1946. It should here be noted that the increase in the number of rural users of electric power has been large during this period and the cost of distribution necessarily greater than might be expected.

A direct result of the long transmission lines required in most of the provinces is the increasing emphasis on the utilization of extra-high-voltage equipment, and the development of several potential hydroelectric sites in northern Canada (at present uneconomical because of the long transmission distances involved) may be justified within a few years. At present, the highest-voltage system operating in the North American continent is the 360 kV system of British Columbia. But already there is good reason to believe that transmission at 650 kV a.c. will be a necessity within the next ten years, and the problems involved in designing the necessary equipment are likely to be severe.

Cass-Beggs scheme

An interesting suggestion has recently been made by D. Cass-Beggs* relating to the feasibility of a large-scale interconnection of generating units across the continent. He has proposed that it might be possible to produce the bulk of the power required for the trans-Canada line at sites where hydroelectric power can be produced economically or where there is an abundance of cheap fossil fuels.

For example, the natural-gas and coal resources of the prairie provinces would be used for the generation of electric power which could be transmitted to any part of Canada. The economic-feasibility study has shown that large economies might accrue from such a transcontinental interconnection system, and Cass-Beggs has suggested a possible technical solution, which is summarized below.

Assuming a transmission line of 3000 miles with an average distance of 500 miles between taps, and capable of handling up to 1000 MW at any point, it would appear that a d.c. transmission system would be more economical than an a.c. system. The two-conductor circuit, with lines operating at $\pm$400 kV d.c., could readily handle 1000 MW over the distances contemplated. It has also been pointed out that the outstanding advantage of a d.c. transmission system is that a synchronous link between essentially independent systems can be provided.

The proposal is attractive for three important reasons:

1. It would be possible to reduce either generating capacity held in reserve for contingencies, or capacity that is constructed ahead of demand
2. A reduction in peak demand owing to the increased diversity arising out of the different consumption patterns in different regions, and more particularly as a result of the displacement of peak-consumption periods in the five time-zones across Canada, could be expected
3. Economies should result, owing to the optimum use of minimum-cost power resources and the maximum use of available energy storage.

Clearly, the technical implications of the trans-Canada transmission-line proposal are immense, especially in view of the elaborate high-power equipment required at the terminal stations (e.g. mercury-vapour rectifiers, transformers and switchgear). The technical feasibility of the proposal, and in particular of d.c. transmission, is the subject of a large-scale study by the National Research Council. Even if the trans-Canada transmission line does not materialize for several years, there will still be increasing need for d.c. transmission to the more remote areas of the country.

Electrical engineering education

There are several dissimilarities between the educational systems of Canada and the United Kingdom. Broadly, the Canadian system is based more on the pattern which has evolved in the United States. In electrical engineering education, the major differences between the Canadian and British systems are outlined below.

Virtually all entry into the engineering profession in Canada is through the universities (at least 95%). As a result, a notable feature of technological education in the United Kingdom, namely the broad spectrum of educational facilities ranging from local technical colleges to colleges of advanced technology and university engineering departments, has no counterpart in Canada.

Comparatively few undergraduate scholarships are awarded at the universities, and the majority of those available are of sufficient value to cover fees only. Most of the students who receive no scholarship support earn adequate funds during the long summer vacation* to cover university fees and maintenance during the university session. Although some students work as paid research assistants in university laboratories during the summer and others work in the electrical industry, the majority undertake a wide variety of work, e.g. in agriculture, with survey crews, in the logging industry, etc.

The motivation provided by the necessity to earn university fees seems to be important in the student's approach to his university work.

At postgraduate level, there is a sufficient number of scholarships available to the more able students, and there is no necessity for postgraduate summer employment.

Less educational specialization

Since the degree of specialization in Canadian high schools is less than in British grammar and public schools, the standard of freshmen in mathematics and physics is lower than in the United Kingdom. For example, no calculus is taught in the majority of Canadian

* 'Economic feasibility of trans-Canada electrical interconnections', *Journal of the Engineering Institute of Canada*, January 1961, 44, p. 53

* The average summer vacation is of 4–5 months' duration

high schools and the teaching of physics is more descriptive than rigorous.

The course for the bachelor's degree is of four years' duration, of which the first two years are common for all branches of engineering, the first year being regarded essentially as a pre-university year which brings the students up to the academic standard of a British university freshman.

In general, the university courses are somewhat broader, with appreciable emphasis on technique, rather than the more thought-provoking type of course that concentrates on fundamental principles. The reason for this is that the intelligence level of engineering students in Canada is, on the average, lower than in the United Kingdom. This is not surprising in view of the fact that entry requirements to the universities in Canada are by no means so stringent as those in Britain.

However, there is increasing emphasis on special courses in engineering: for example, the courses in engineering science that have recently been launched at the University of Saskatchewan. These advanced courses are essentially for the more gifted students with a flair for mathematics and the physical sciences.

Comparatively few students have had practical training in industry before entry to the university, and few have had industrial experience before graduation. This is to some extent compensated for by the summer work and, especially in the western provincial universities, by the fact that many engineering students have been brought up on prairie farms and have an inherent gift for handling mechanical and electrical equipment.*

More earnest

There has been a notable increase in enrolment in graduate schools of electrical engineering during the past few years, and the demand for graduates with master's and Ph.D. degrees is high. The standard of these schools is comparatively high, and the students are required to undertake a research project of reasonable scope. In addition, they must take courses in advanced mathematics and advanced electrical engineering, and are required to pass examinations at this level. These courses and the thesis requirements coincide closely with the post-graduate courses available in United States universities.

My over-all impression is that the average Canadian student is more earnest than the average British student, and I consider that the reason may be the greater motivation of the Canadian student. The problem of working during the long summer vacations, sometimes in difficult physical conditions, in order to obtain university training is clearly a powerful influence in the motivation of the students, who, at all social levels, must work hard to obtain their education. This also has the effect of instilling a sense of responsibility in the student at a comparatively early age, and this appears to stimulate him in a most effective way.

* Many farms are in comparatively remote areas of Canada, and the requirement for the farmer and his family to be self-supporting, even in the maintenance of complicated farm machinery and equipment, is mandatory

Research in electrical engineering

Until comparatively recently, most research in electrical engineering was carried out in the laboratories of the National Research Council, the Defence Research Board, Atomic Energy of Canada Ltd., and of some industrial research groups. But recently there has been a notable increase in research carried out by the university departments of electrical engineering. There are two basic reasons for this: first, financial support for university research on an ever-increasing scale has been provided by the Federal Government and is administered by the N.R.C. and the D.R.B. Secondly, with an expansion of research and development activities in the Canadian electrical industry, there has been a greater demand for graduates with research training.

It is interesting to note that, although support for students at undergraduate level is not appreciable by British standards, support for students undertaking higher-degree work is more generous than that provided in Britain. And each year, almost 17% of the graduating class in electrical engineering proceed to postgraduate work. For example, of the 600 electrical engineering students expected to graduate at bachelor's level in 1961, it is anticipated that about 100 will proceed to master's and doctor's degrees.

In view of the importance of electric-power generation and distribution in the Canadian economy, it will be clear that a considerable proportion of the research effort in electrical engineering is carried on in this particular field. Of special note is the work on d.c. transmission and on equipment for the extra-high-voltage projects which are anticipated. In the latter connection, developments in the field of circuit-breakers are in hand and the development of gas-filled capacitors for outdoor installation, capable of operating at voltages up to 750kV, is proceeding rapidly. The possibility, subsequently, of using semiconductor devices in the rectification of extra-high voltage is another field in which intensive study is taking place.

Communication research

The field of communication is receiving much attention because of the special problems encountered in Canada. For example, a new technique for low-power long-range (600 miles) radiocommunication, known as 'meteor scatter', has been developed in Canada during the past eight years. This communication system is essentially of low channel-capacity and requires a low-power transmitter operating in the 2–3kW range at frequencies of about 50Mc/s. The system is likely to prove useful for communication with far-northerly communities because it is comparatively inexpensive.

The alternative method of communication over ranges of up to 400 miles is the 'tropospheric scatter' method which, although capable of handling high channel-capacities, is nevertheless non-mobile and extremely expensive. The leading Upper Atmospheric Research Laboratory in Canada, located at the University of Saskatchewan, has

a major part of its programme devoted to studying the upper atmosphere from the viewpoint of communication.

The Saskatoon area is one where strong auroral influences are in effect, and it is an ideal site for upper-atmospheric studies. Moreover, the high-power radar equipments which have been located in northern Canada are also providing a wealth of valuable information in connection with the transmission characteristics of the upper atmosphere.

Several strong teams of investigators are working in the field of semiconductors, both in the universities and in industry. For the most part, the research is in circuit techniques rather than in the development of semiconductor devices. The group headed by N. F. Moody at Saskatoon is, for example, carrying out investigations and applications of tunnel diodes operating as ultra-high-speed switches.

Biomedical engineering

In the field of biomedical engineering, which is closely related to medical electronics, several important groups have been established during the past few years. Perhaps the most notable is the one at the Princess Margaret Hospital, Toronto, which is headed by H. E. Johns, the inventor and builder of the first cobalt-therapy unit. This group has also developed a new type of 'brain scanner' and a 'body scanner' for the location of tumours.

A highly encouraging feature of the researches in biomedical engineering is the close collaboration which has been achieved at several universities between the departments of electrical engineering and those of medicine. Effective medical-engineering groups have already been established at the Universities of British Columbia, Saskatchewan, McGill and Toronto. At the University of Saskatchewan, for example, an electrical engineer has been appointed lecturer in biomedical engineering in the College of Medicine and is the first non-medical member of the faculty.

With such close collaboration, it is not surprising that some important developments are in hand, and it is my view that the 'academic climate' is more favourable in Canada for such collaboration than it is in the United Kingdom.

Digital data handling

Encouraging advances have been made recently in digital-data-handling techniques. One noteworthy example is the automatic airline-passenger-reservation scheme which is due to be installed across the country in 1961.

This system has several unique features, both from the viewpoint of its data-handling capabilities and from the essentially communication aspects—it may be the most advanced reservation scheme in operation in 1961. Further, perhaps the first fully automatic letter-sorting system, incorporating a high-speed electronic computer, has been developed in Canada during the past five years.

General interest in the whole field of data-processing is considerable, and several banks and insurance companies are already installing high-speed data-processing equipment. Both the large railway companies are fully equipped with electronic data-processing equipment, and it is used as well for handling routine operations such as payroll computations, the optimizing of train-running schedules, and the handling of freight. Indeed, perhaps the most notable feature of the Canadian railways today is the increasing emphasis on integrated data-processing, and this is to a large extent being handled by electrical engineers.

There is a refreshing and light-hearted approach to research in electrical engineering, and the average young Canadian research worker is usually a first-class improviser and appears to be unperturbed by the most ambitious of research programmes. Unquestionably, the electrical engineer is spearheading the industrial growth of Canada, and important advances on a broad front may be expected in the 1960s.

Summary

The recent rapid expansion of Canadian industry has necessitated an accelerated programme of electrical generating-plant construction. And this development has focused attention on electrical engineering education and research. This article has surveyed present and anticipated developments in generation and research, and has discussed some differences between the electrical engineering educational programmes in the United Kingdom and Canada.

Technical standards for electronics industry

An interlocking system of standards for the electronics industry is to be set up. At a recent meeting of Western European national standards organizations, it was agreed that the 13 countries in the Free Trade Association and the European Economic Community should collaborate in the formulation of standards for Western Europe's electronics industry. It was proposed that this end be achieved by developing and promoting the use of performance standards from such bodies as I.S.O., I.E.C., C.C.I.T.T., C.C.I.R. and C.E.E. The proposal has received the support of seven British industrial organizations in the electronics field.

NEW FILMS ON NUCLEAR REACTORS

Two films concerned with the operation of Calder-Hall-type reactors are now available on free loan from the Central Film Library of the Central Office of Information.

The first (UK 2177 **Operating a Calder Hall reactor — refuelling**) deals with the operations involved in the discharge of fuel and its replacement with new fuel elements. The second (UK 2178 **Operating a Calder Hall reactor — full power**) is devoted to the operation of the reactor for the production of electricity.

These films may be obtained by applying to the Central Film Library, Industrial Section, Government Building, Bromyard Avenue, Acton, London W.3.

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Trials and tribulations of a service engineer

At the Inaugural Meeting of the Bedfordshire Sub-Centre of The Institution on the 21st November 1960, the Chairman's Address took the form of 'a most informative and amusing talk' (see January 1961 Journal, p. 62). This article is based on part of the Address. Mr. Taylor is with Brookhirst Igranic Ltd.

J. RUSSELL TAYLOR, T.D., B.SC., M.I.MECH.E., MEMBER

EACH kind of engineering business has its own type of trouble, and probably the control-gear manufacturer has a bigger field to cover than most. This is because he supplies auxiliary equipment for use with other manufacturers' equipment, and such equipment is used in a very wide range of industrial activities.

There are, of course, internal and external difficulties, i.e. troubles inside the factory and those outside. This article discusses the latter.

Looking back over the years, a number of problems stand out, and they fall into fairly well defined classes, such as: manufacturing, faulty materials, poor design of components, faulty maintenance, lack of essential information from customer, incorrect information from customer, wrong application, and attempting to flout the laws of nature. Some examples are worth considering, especially since engineers should try to profit by their failures.

Noise abatement

The writer has been what the Americans aptly term a 'trouble-shooter' since practically his first day in engineering and, as an apprentice, was sent out on a number of erection jobs, helping a fitter to erect cranes. On one crane, when the a.c. supply was switched on (by pressing the 'on' button of the crane protective panel), there was a deafening and all-pervading noise. It appeared to come from the hoist motor, but on listening to that motor it was evident that it came from the slewing motor.

After we had crawled all over the machinery house, the noise was finally traced to the main contactor of the protective panel. The contactor had been incorrectly assembled by the manufacturer. The armature butted hard on the lower pole-piece and was about $\frac{1}{16}$ in. clear of the upper pole-piece. The noise was cured for the official test by temporarily packing up the bearing; but, as the manufacturer had been notified, the packing was removed to give his man something to do when he arrived.

During the early life of blast furnaces there are many troubles. These examples may be of interest.

Reversed interpoles

A d.c. generator, when put on load, sparked violently at the brushes. The control gear was suspected, and the local control-gear engineer was called in by the electrical consultants. As no amount of brush-gear shifting cured the trouble, they discussed it in the hotel and finally diagnosed reversed interpoles. Next morning, bright and early, the experts returned to the job and reversed the offending interpoles. The generator was started and loaded, with the same sparking at the brushes.

At this point the night foreman appeared and said 'Well, the trouble is now over', whereupon the experts said 'Look'. He said 'That's funny—it was all right after I reversed the interpoles last night'.

Brake lubrication

Skip-hoist limit switches were very difficult. Practically all skip-hoist winches were fitted near the bottom of the furnace: two ropes went over the pulleys at the top, and the ropes were connected to two skips. When one skip was at the bottom, the other skip was upside-down at the top. It was essential that the bottom skip should be in the correct position to receive the charge and should not bump on the ground. Similarly, the upper skip had to tip far enough, but not too far.

Most troubles were due to attempts being made to compensate for rope stretch by adjusting the two points on the limit switch, which was connected to the winch. One would imagine that it would be obvious that, when the rope stretched, the upper skip would not reach the correct position and the lower skip would bottom; also that this applied whichever skip was at the top. Attempts were made to correct this by adjusting the limit switch, to no effect.

A blast-furnace manufacturer had endless trouble on a skip hoist which overran with great regularity. This went on for months. One day their engineer was leaning on the rail round the winch, wondering what could be wrong, when a man climbed up the ladder, went across the platform and threw something on the brake-wheel. The engineer suddenly woke up and said 'What did you throw on the brake-wheel?', getting the reply 'Oh, a lump of fat'. 'Have you done this before?' 'Oh yes, I have to do it nearly every shift—when the skip stops short!'

Too many teeth

A method of making seamless tubes consisted of piercing a billet into a bottle shape. The end of a mandrel was pushed into the hole in the bottle, and the bottle and mandrel were forced through a series of dies, thus smearing metal over the mandrel. The tube was then loosened by passing it through a set of rollers, and the mandrel was withdrawn. As the front end of the mandrel was then hot, it was turned round on a turntable before being used again. The mandrel turntable had a limit switch so geared to it that it stopped at each 180° rotation.

On one installation there was great difficulty in adjusting this limit switch, and finally it was clear that there must be something wrong with the gearing. The writer asked the main contractor's engineer for the gearing drawing, and on going through it discovered that the gearwheel attached to the limit switch had 100 teeth instead of the correct 96.

The contractor's engineer rang up his works, who said they required three weeks for a new wheel. The wheel was put in the author's car while he was ringing up *his* works asking for a turner to stay behind. The wheel was turned, recut to 96 teeth, and returned to site by 8.30 a.m. next day.

Waiting for the crash

A different type of snag occurred during the acceptance tests of a coal-wagon hoist of a well known type (Fig. 1), which was provided with a d.c. motor. Normally, it hoists and tips a full wagon and lowers an empty wagon, and it is balanced to the weight of a wagon plus half the load. During tests, a full wagon and an empty wagon were to be hoisted and lowered. While the empty wagon was being hoisted, one of the engineers leaned against the handle of the main circuit-breaker at ground level and tripped the breaker.

The balance weight took charge and the motor tried to regenerate, but as there was no circuit to absorb the power it was driven faster and faster. The writer pressed the emergency-stop button, but by this time the voltage from the motor was so high that the contacts merely fizzled and would not break the circuit. He then ran up the ladder as fast as he could, arriving just before the wagon, and jumped on the brake-weight in an attempt to put it on but could not do so, so could only wait patiently for the crash.

Luckily, owing to the mechanics of the hoist, the crash never came, and the wagon came to rest before the final stops. All later hoists, of course, were fitted with special overvoltage relays to prevent a recurrence.

A premature opening

On one site, control gear for a number of moving bridges of the Scherzer rolling-lift type was provided (Fig. 2). When the first bridge was ready, the writer was called in because the resistors got red-hot. The motors were d.c. compound-wound, and the control gear had a low-speed notch where all the starting resistance was in circuit, with a diverter resistor connected across the armature, thus giving a steady low speed. A two-minute-rated resistor was specified, but on the first closing of the bridge the low-speed notch was used throughout: an operation which took 20 minutes. On later jobs, much larger resistors were fitted, whatever the specified rating.

This bridge, being the first of the series, was to be opened with great pomp and circumstance. It was decided that the first ship to use the new dock entrance, over which this bridge was built, would come to the entrance, and the wife of the governor of the harbour authority would declare the bridge open and, by removing a pen from the presentation inkstand, would open the bridge.

The writer was called to London for a meeting with the consulting engineers and was instructed to bring a number of different plugs and sockets, so that a suitable pair could be used to make a connection between workshop flex from the ship and a similar flex from the control circuit on the bridge. A suggestion that an electrician with a pair of pliers and some sticky tape could do the job much better and more cheaply was ruled out.

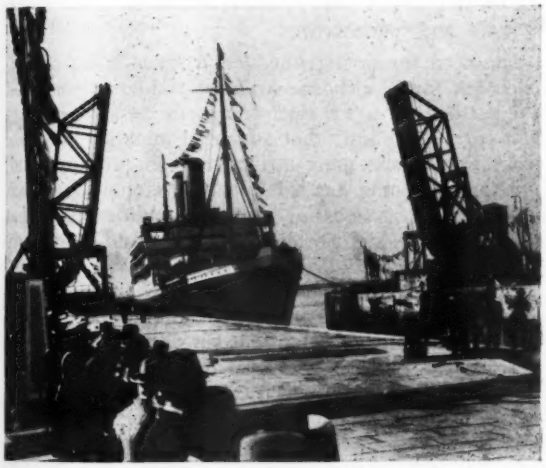
When the great day came, the bridge manufacturer's chief engineer took the inkstand, with its wire, on board ship out in the roads, while the writer had to arrange the

1 *Railway coaling plant showing coal-wagon hoist*

shore end. Beside the bridge was a very long luncheon tent, a brass band, and thousands of spectators. The roller-paths of the bridge were fitted with a series of railway fog-signals, and the structure was bedecked with flags.

The ship arrived just in the harbour mouth; and two very powerful dockers, heaving on a heavy line, to the end of which was attached the workshop flex, got the plug ashore. When the plug was put into the socket, there was, to everyone's surprise but the writer's, no circuit. An electrician was sent to pull the wires out of the plug and socket and make a proper joint, after which the control circuits were tested three times.

The 'all correct' signal was sent to the ship and answered by the ship, by which time the programme was 20 minutes late. On receipt of the 'go ahead', the main switch on the bridge was closed, and a few seconds later the bridge began to open, the fog-signals went off, the band played, and the ship began to come in. There were loud cries from the ship's bridge of 'Stop the ship', 'Close the bridge', and 'It's a mistake'; but by this time the



2 *Double-leaf rolling-lift bridge*

ship was under the bridge, so it had to be hauled back before the bridge could be closed.

Three-quarters of an hour later, there was a movement on board ship, the bridge opened and the ship came through; but there was no brass band and there were no fog-signals, nor were there many people to see the ship come through, as most of them were in the tent having lunch.

About a week later, the engineers involved on the manufacturing side received irate letters from the consultants, who wanted to know on whose authority the bridge had been opened prematurely. Apparently what had happened was that the late 'Jimmy' Thomas had spoken for two hours after lunch on board the ship.

Valuable training

The preceding instances show that, although the control is almost invariably blamed for trouble, it is not invariably at fault.

Service visits are an essential part of a professional engineer's training and, as such, should be sought after by all young men. They introduce the young man to other branches of engineering and sometimes totally different kinds of business, thus broadening his mind and increasing his vocabulary. Such training is most useful; and it is helpful to an engineer, when discussing business problems with a customer, to be able to visualize his requirements and talk his language.

Some employers seem to think that it is good enough to send anyone to see what has gone wrong, but this is a great mistake, since the customer is looking for an expert who can rectify the fault, not for someone who has to return to the works to find out what to do. The best man available should be sent, even though the report indicates trivial trouble. The report is frequently misleading. The service engineer who has a reputation for being able to put his finger on the spot and, if necessary, redesign on site is the firm's best salesman.

High-power short-wave transmitters

THE British Broadcasting Corporation have announced the installation of two new 100 kW short-wave transmitters at their External Services transmitting station at Rampisham, Dorset. The first of these began operation on the 5th March, while the second was planned to start transmission sometime in April.

The four original transmitters at Rampisham have been in continuous use since 1940, with an average total programme output of 78 hours daily. These transmissions are directed mainly to Africa, the Middle East, South-East Asia, and North and South America.

Design innovations

A feature in the design of the new equipment is the vapour cooling that is used for the valves in the final r.f. amplifier and modulator stages. The heat from the valves is transferred to surrounding water jackets and steam is produced; the steam is carried by convection to an air-cooled condenser which reconverts it to water, which is returned by gravity feed to the water jackets.

The new equipment can carry out a frequency change in a few seconds, an important advantage in short-wave broadcasting because carrier frequencies must be changed often to accommodate varying propagation conditions. This is effected by provision of two r.f. amplifiers for each transmitter, located on either side of a common modulator. Thus, while one amplifier is being used the other can be set up on another frequency and the frequency change can be made almost instantaneously.

As well, a new form of electro-pneumatic switch, remotely controlled from inside the station, enables the output of a transmitter to be connected to a selected aerial feeder, thus ensuring a maximum signal in the target area. This new development by B.B.C. engineers will assist the rapid selection of the correct aerial array for each particular schedule.

ELECTRICITY AND ELECTRONICS IN AVIATION

629.13 : 621.389 : 621.311.161

This article discusses the ways in which aircraft and air traffic rely on various applications of electrics and electronics; the necessity for reliability is specially emphasized. The subject-matter is derived from a lecture delivered to a Joint Meeting of The Institution and the Royal Aeronautical Society at Savoy Place on the 11th November 1960. The lecture was published in Part B of the Proceedings in March 1961. The author is with the English Electric Co. Ltd.

The Rt. Hon. The VISCOUNT CALDECOTE,
D.S.C., M.A., ASSOCIATE MEMBER

THE importance of electricity in aircraft and missiles today needs no emphasis, and this importance is increasing steadily. In missiles this is simply because the requirements are becoming more and more severe, and electrical methods provide the only way to meet them; there seems every reason to suppose that this trend will continue and that the techniques and systems developed for missiles will increasingly be adapted for use in aircraft and other manned vehicles of the future.

Similar considerations apply to the growth of electricity in aircraft (see Fig. 1), but here there is another important factor. Not only have there been new requirements, such as radio, navigation and air-conditioning, since aircraft first flew, but many functions which were formerly performed satisfactorily by the pilot can no longer be done unaided. These include operation of control surfaces in high-speed aircraft, navigation in congested air space, and landing particularly during bad weather.

So electricity and electronics must come to the pilot's aid. But such problems present special difficulty in an airborne environment owing to the importance of weight- and space-saving and, above all, reliability in all conditions of flight.

Heat problems

In high-speed flight the temperature rise due to the speed itself is significant, and at high supersonic speeds it prevents the use of conventional power circuits. For instance, the effect of these high temperatures on generating equipment is to enforce the use of artificial cooling, since the magnetic properties of iron deteriorate rapidly above 400° C. Difficulties also occur at elevated temperatures because of the oxidation of copper under the insulation. The problem of finding an insulating material capable of standing up to these temperatures is great.

At present, silicon-elastomer glass-fibre construction, with fluorocarbon insulation in particular hot spots, is suitable for flight speeds up to Mach 3, but above this speed wholly mineral insulation will be needed. Plugs and sockets also present a major problem, owing to migration and oxidation placing a limit on silvered mating surfaces. Undoubtedly the elimination as far as possible of all connecting devices is a worthwhile target, and the progress of miniaturization will help to achieve this.

Weight- and space-saving

The need for saving weight and space is, of course, axiomatic for all airborne structure and equipment, and it is particularly so for electromagnetic devices requiring iron cores; it follows that advanced methods of power generation appear more attractive in the aviation field, and this reasoning has led to the development of such equipment as brushless oil-cooled alternators running at 8000 r.p.m. with high power/weight ratios and satisfactory reliability.

All these requirements tend to increase the complexity of electrical apparatus in modern aircraft, and this in turn runs counter to conditions for optimum reliability. The progress that has been made over the past ten years in the development of electrical components and techniques has been of the greatest significance in both aircraft and missiles.

At the Joint Meeting with the R.Ae.S.
Left to right: Lord Caldecote; Dr. E. S. Moult, President of the R.Ae.S.; and Sir George Edwards

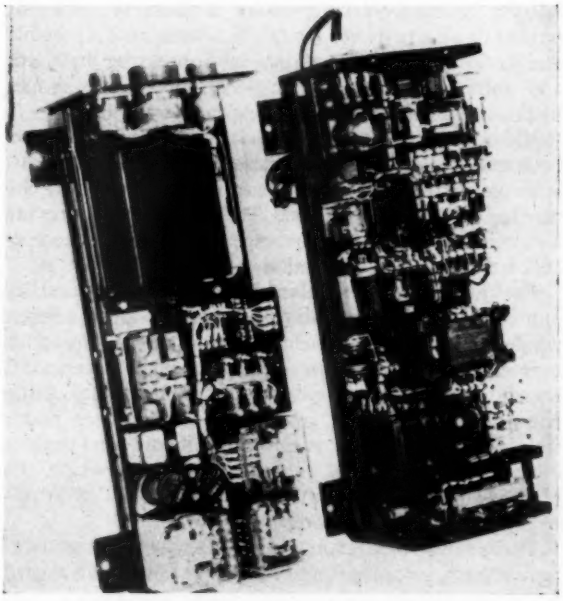
Much of the stimulus has indeed come from the necessity to compress more and more complex circuitry first into military aircraft, then into guided weapons and now into space vehicles: this is one of the factors that make it essential for Britain not only to continue missile development but to take a substantial part in space research.

Already civil aircraft and industry generally are benefiting from this progress: high-powered radar, Doppler techniques, semiconductors (Fig. 2), computers and microminiaturization are a few examples.

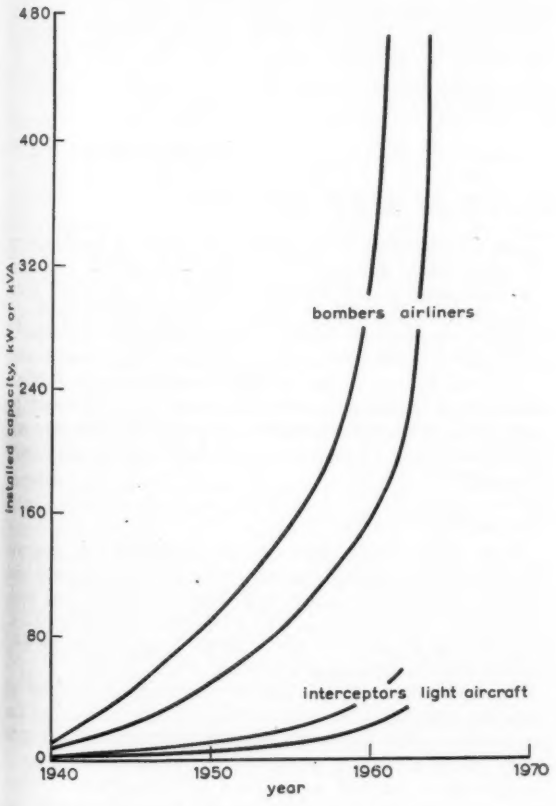
Flight-information problems

From the earliest days of flying, the presentation of adequate flight information to the pilot has been of great importance. Initially this was confined to crude displays of indicated air speed, height and fuel state, all from instruments operated directly without the help of electricity.

Increasing speeds have cut down the time available to the pilot, particularly in the critical take-off and landing phases; high fuel consumption and the requirements of air-traffic control have made accurate navigation essential for both safety and economic reasons; and the requirements for safe and accurate flying in bad weather have greatly added to the amount of information required by the pilot from his instruments.



2 *Circuit simplification employing semiconductors*
(left) control panel incorporating transistors
(right) conventional aircraft control panel



1 *Trends in aircraft electric-power requirements*

In flight-control systems it has been shown that, by using redundant systems or circuits and maintaining their outputs, a sufficient degree of safety can be achieved for automatic landing of passenger aircraft. Automatic flare-out and fully automatic-landing systems are being developed and excellent progress has been made—quite sufficient to justify the plans being made to incorporate these systems in the VC10 and DH121 aircraft—but it will be a number of years before they are in service.

The problems of data transmission and processing are becoming increasingly important. The increasing density of air traffic and the short flight-time of guided missiles both pose the problem of rapid data transmission and the swift transposing of this data into usable form.

With manned aircraft it is becoming quite outside the capability of human air-traffic controllers to assimilate all the information and to make the decisions necessary to ensure the safe and orderly flow of traffic. With increasing speed, a similar problem is developing for the aircraft crew, and the automatic transmission, processing and display of information in a convenient form are assuming great importance; this may well be followed ultimately by the direct control of the aircraft via a data link.

Air-traffic control

As the air space becomes more and more congested and average speeds increase, it is doubtful if any air-traffic-control system will be able to ensure complete freedom from risk of collision. The development of a reliable collision-warning device is urgently required; it must be able to detect aircraft that constitute a possible danger in time for the relative motions to be analysed, and only those that may cause risk of collision should be brought to the pilot's attention.

Already, visual warning even in good weather is inadequate, and until a reliable warning system, at least, is available the hazard of collision will increase as the new big jets come into service. The difficulty is to provide a system with sufficient coverage yet without unacceptable weight and space penalties.

The advent of inertial-navigation systems, first in unmanned missiles and now in aircraft, is introducing a whole new field of development in connection with gyroscopes, accelerometers and associated equipment. In addition to work on low-friction bearings using conventional principles, investigations have been under way for a number of years into radically different designs of gyroscope, such as gimbal-less ones in which the rotor is supported without mechanical contact by means of magnetic or electric forces.

There will also be further progress towards miniaturization of both gyroscopes and accelerometers. With regard to the latter, there are some interesting possibilities using the vibrating-string principle with electrical pick-offs or the piezoelectric effect in crystals, but the problems of stable operation in a changing environment have not yet been solved.

The challenging future

There is no end to the applications of electricity and electronics in aeronautic vehicles of all kinds. The search for higher performance combined with lightness, smallness and reliability will continue unabated and will present challenging and fascinating problems to engineers and scientists. As well as technical skill and initiative they will need wise judgment to balance the claims of rapid and exciting advances against the cost in money and reliability and, with manned vehicles, in risk to human life.

Certainly there is no more stimulating field of development than this, and there is little doubt that aeronautical electrical engineering will continue to set the pace in an important section of industry; for this reason, quite apart from any direct value to the aviation industry, it is of the utmost importance to Britain that aeronautical and electrical engineers work more and more closely together.

Summary

The dependence of manned and guided flight on equipment reliability cannot be overemphasized. Further work on air-traffic control and collision-warning and automatic-landing devices is urgently needed, while the development of data-handling techniques for airborne use must be pressed forward. All this will lead to increasingly complex systems whose reliability must be continuously and rigorously enhanced.

Nestor in operation at Winfrith

NESTOR, a new 10kW nuclear reactor, was recently put into operation for the first time at the U.K.A.E.A. Atomic Energy Establishment, Winfrith, Dorset. It acts as a source of neutrons for sub-critical assemblies of nuclear fuels and moderators. The assemblies adjacent to the reactor are used to obtain experimental data for graphite, natural-water and heavy-water moderated power reactors.

The new reactor yields a thermal neutron flux of 10^{11}neutrons/cm^2/sec in the centre of the core and up to 10^8neutrons/cm^2/sec in the subassemblies. The thermal neutron flux for each sub-critical assembly may be varied by altering the reactor power level, by using neutron shutters or by rearranging the fuel loading in the annular core.

Fuel and control

The fuel used in Nestor is a highly enriched uranium and aluminium alloy in the form of aluminium-clad plates arranged in an annulus around a graphite cylinder. Natural water is used as both coolant and moderator.

The reactor is furnished with control and safety rods; additional control is obtained by varying the water level. The experimental assemblies are placed in 'caves' formed in the shielding above and at the sides of the reactor.

The whole shielding is arranged to be demountable so that the caves may be rebuilt to accommodate major changes in the requirements of the experimental programme.

CHILTERN RADIO STATION

THE Government have decided to allow a British Post Office radio station to be built west of the London–Fishguard road (A. 40). The site chosen is on land belonging to Kiln Farm in the Chiltern village of Stokenchurch, Buckinghamshire. The decision followed a recent local public inquiry, arranged by the Minister of Housing and Local Government.

The Post Office will use building materials that will blend with the surrounding countryside, and the station will be screened by trees. The structure will be about 75ft square and 13ft high with a radio tower 250ft high and of maximum diameter 55ft.

The search for a site

In his report to the Minister, the Inspector said that the area had been carefully studied over a four-year period and that the search had yielded only seven locations that were suitable for the station. He added that the possibility of discovering more sites was not sufficiently strong to warrant further delay in arriving at a decision.

The Kiln Farm site was finally recommended because of technical considerations and in the interests of causing the least harm to the Chiltern landscape. The station will form a key link in a network of stations to be employed for maintaining communication in the event of military attack, while its civil uses will include telegram, trunk-telephone and television-relay services.

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BRITAIN'S FUEL RESERVES

The implications for the electrical engineer of Britain's fuel reserves are discussed in this article. The author was President of the World Power Conference from 1950 to 1956 and is the Honorary Chairman of its International Executive Council. He has held high office in no less than four major industries—railways, fuel, airways and electricity supply—and has been responsible for advising all of them on research.

Sir Harold was elected an Honorary Member of The Institution in 1957 in recognition of his life-long interest in all aspects of engineering and for his studies of the conservation of natural resources.

Sir HAROLD HARTLEY, G.C.V.O., C.B.E., M.C., M.A., F.R.S., HONORARY MEMBER

BRITAIN's coalfields and the development of the steam engine were the main sources of her industrial supremacy in the early decades of the 19th century. Today, while many other countries have within their borders much hydro-power and supplies of oil and natural gas, Britain is still dependent almost entirely on coal for her indigenous supplies of energy, and so her coalfields, like Dr. Johnson's friendships, should be kept 'in good repair'.

Coal reserves

Several comprehensive estimates have been made of the extent of Britain's coal reserves. The Royal Commission of 1871 put them at 146000 million tons in 1870, the Royal Commission appointed in 1901 at 142000 million tons in 1905. Strachan in 1913 estimated them at 179000 million tons in 1912, and Prof. H. S. Jevons in 1914 raised this figure to 197000 million tons. All these estimates referred to seams of coal 12in. or upwards in thickness and within 4000ft of the surface, and no attempt was made to discriminate between different types of coal.

The Coal Survey Laboratories of the Fuel Research Board from 1921 onwards had been accumulating information about the character of the coal in all the fields; and, after the Coal Act of 1938, the work of the Regional Valuation Boards, with the co-operation of the Coal Commission and the Geological Survey, made it possible for officials of the Coal Survey to make estimates of the amounts of different classes of coal likely to be mined in the period from 1942 to 2042 in each coalfield on the assumption that the gross output would be 200 million tons a year, drawn from seams 3ft or more in thickness and not deeper than 4000ft.

The results of this rapid survey were published by the Department of Scientific and Industrial Research as a Fuel Research Survey Paper (no. 58) in 1946. They showed that over 75% of the coal likely to be mined in this period was of high-volatile character, adaptable to many purposes.

However, this survey dealt with only 20000 million tons of coal, and the known reserves are much greater, as shown by the earlier estimates. Taking a conservative view of the proportion likely to be mined economically, the practical reserves may be put at 50000 million tons, sufficient for 250 years' output at 200 million tons a year.

The indigenous reserves of other forms of fuel are very small in comparison with those of coal:

Form of fuel	Tons of coal equivalent
peat	500 million
oil shale	20 million
hydro-power	5 million p.a. (if fully developed)

Primary-energy demands

Table 1 shows how the primary-energy demands of the United Kingdom (i.e. England, Wales, Scotland and Northern Ireland) were met in 1928, 1938, 1948 and 1958.

The figures emphasize the increasing part that imported oil is playing.

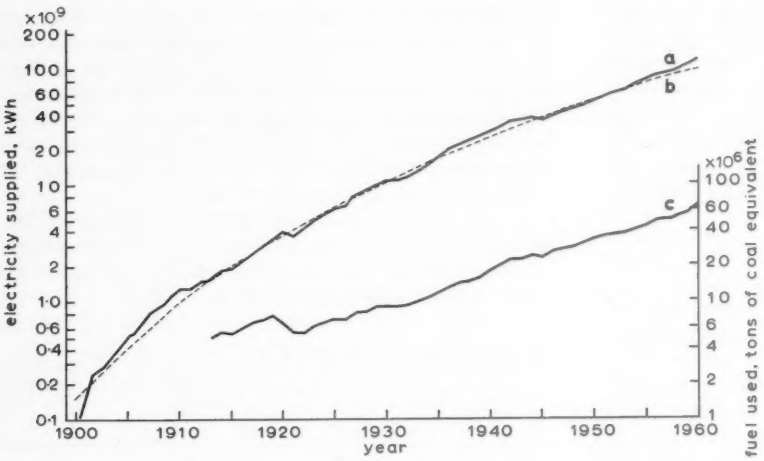
Table 1. Contributions to primary-energy demand in million-tons equivalent of coal

	1928	1938	1948	1958
coal	167·7	175·7	192·1	199·1
oil	8·0	13·0	19·3	47·6
hydro- and nuclear power	0·1	0·7	0·9	1·6
total	175·8	189·4	212·3	248·3

Over those years there have been large fluctuations in the total consumption of energy owing to various causes —war, industrial recessions and labour disputes—but a striking fact is the steady increase in the consumption of energy in Great Britain (i.e. England, Wales and Scotland) in the form of electricity, as shown by curve **a** of Fig. 1. This today continues to increase at around 7% compound per annum, while the increase in the gross consumption of primary energy averages about 2% compound in recent years.

The trend of consumption since 1953 has been above curve **b** in Fig. 1, which follows the average trend from 1900 to 1950 and is extrapolated to the year 1960. The estimated consumptions from 1965 onwards, given at the

end of this section, have been based on the average trend since 1953. Curve c of Fig. 1 shows the steady increase in the consumption of fuel used for the production of electricity.



1 *Long-term trend in electricity supplied and fuel used in Great Britain*

a electricity supplied by public-supply power stations
b average trend of electricity supplied
c fuel used for the production of electricity

The amounts of primary energy from various sources used in public-supply power stations in Great Britain and the changes in their percentage contributions are given in Table 2.

With the emergence of a new major source of electricity from nuclear energy, the electrical engineer must forecast what are likely to be the most economical means of electricity generation in the years to come so that he can plan his construction programme to meet the growing demand.

This is likely to be 160000 million kWh in 1965, 230000 million in 1970 and 330000 million in 1975.

Nuclear power

The programme of nuclear stations has been laid down in successive White Papers, the most recent of which sets out the basis for the installation of nuclear plant in the next few years and envisages a steadily rising rate of nuclear commissioning which should give the country about 5000 MW of such capacity in 1968. The total capacities likely to be needed in future might therefore be as follows:

Year	Plant output capacity	
	All stations	Nuclear stations
	kW × 10⁶	kW × 10⁶
1965	41·8	2·9
1970	58·3	7·1
1975	81·4	13·3

At each stage, as decisions have to be made, the engineer will have to consider how to combine nuclear and conventional methods of power generation to provide for the increased demands for electricity most cheaply.

Here he is faced with problems outside his control—the future prices of indigenous coal and of imported oil and possibly natural gas, and also the certainty of the availability of these supplies.

Mechanization of coal-mining

Britain's coal industry is in a state of transition, as large investments are being made in mechanization and there has been a complete change in the methods of mining coal. The pick and shovel gave way, first, to the coal-cutter and, more recently, to power-loading machines that cut and load the coal onto conveyors as they traverse the face.

This change has necessitated a revolution in the types and systems of roof support. The advantage of these developments in the winning of coal is seen in the latest figures for the number of man-shifts required to produce 1000 tons of coal at the coal face. For non-mechanized faces, this is 254; for mechanized faces, 150. In the East Midland Division the latter figure is 120, the best figure for an Area being 92. Mechanization has reduced the cost of winning some types of coal more than others; this is specially true of small coal and fines acceptable to electricity generating stations, and new investment is being concentrated on the coalfields with the lowest production costs.

Clearly this is a field of common interest to the Central Electricity Generating Board and the National

Table 2. Amount of primary energy from various sources used in public-supply power stations, and their percentage contributions

	1928	1938	1948	1958	1928	1938	1948	1958
	million tons coal equivalent				percentage			
solid fuel	8·23	14·19	28·06	46·34	98·2	95·1	96·6	88·9
oil	0·05	0·03	0·08	4·37	0·6	0·2	0·3	8·4
hydro-power	0·10	0·70	0·90	1·40	1·2	4·7	3·1	2·7
total	8·38	14·92	29·04	52·11	100	100	100	100

Coal Board, and it is pertinent to ask the following questions. Is the N.C.B. ready to make long-term contracts with large users of the coal that can be produced most cheaply without subsidizing the users of the more expensive types of coal? Are the cheapest-producing fields (East Midlands and Yorkshire) well situated with regard to the future siting of generating stations or those likely to be modernized in the near future?

Challenge of oil

Turning now to oil, the new oilfields in the Sahara and Libya, and the increased output in the Middle East, have changed the outlook for Europe. At present, there is a glut of oil, and prices in some areas show a substantial economy over coal. How long is that likely to continue? What are the chances that natural gas will be piped from the Sahara to Britain at a cost that will compete with home-produced coal? These are some of the problems that the generating engineer has to consider.

In another field the modern development of pipelines has started new thinking as regards the cost of the transport of energy. Sea transport is the cheapest by means of oil tankers, followed by colliers with more-expensive terminal-handling costs. On land the oil pipeline is the cheapest method, followed by high-pressure gas lines, particularly if the gas is produced under pressure, then by h.v. overhead lines, with coal by rail the most expensive of all except for short distances and poor load factors. The new installation of a hydraulic coal pipeline in Ohio is showing a considerable economy over rail haulage with a guaranteed annual load of 1¼ million tons over a distance of 105 miles. What are the prospects for similar developments in Britain?

Gasification of coal

One other development might be significant. If the scheme for the complete gasification of coal at the pithead in pressure plants of various types (the Lurgi plant is already well established) should produce cheap industrial gas, it would offer the possibility of the development of a high-pressure combustion-chamber-burning gas, with savings both in the capital and operating costs of power stations. Against such a development it may be argued that in a modern steam station the fuel costs represent approximately two-thirds of the operating costs and capital charges less than one-third.

Hydroelectric generation

Coming now to hydroelectric generation and pumped storage, the latter does not add to the fuel supply, but where geographical conditions are favourable, i.e. a low ratio of horizontal to vertical pumping distance, it can improve the economy of generation by its effect on the load factor. Pumped storage would be of particular value in connection with nuclear stations, with their high capital costs and need to run at a correspondingly high load factor.

Hydroelectric generation can never contribute more than a very small part of the country's generating requirements. The North of Scotland Hydro-Electric Board and the South of Scotland Electricity Board have in operation or under construction hydroelectric plant with a potential output of about 3300 million kWh by 1965. The unharnessed hydroelectric potential was estimated in 1944 at 6274 kWh and is now thought to be greater than 10000 million kWh if it were all developed. So the output in 1965 will represent a saving of 1·7 million tons of coal equivalent per annum and the potential output a saving of 5 million tons of coal equivalent.

The future

In view of all the factors that have been outlined in this article, what are likely to be the contributions of the various energy sources to electricity generation in the next 15 years? Obviously much will depend on the relative prices of coal and oil at the point of consumption in the future, dependent on factors that lie outside the scope of this article. Two forecasts up to 1975 have been made for Great Britain. Any attempt to extrapolate beyond 1975 would be guesswork, as so much will depend on the trend of demand and on the relative prices of the various forms of primary energy and the cost and efficiency of their conversion to electricity.

Table 3. Possible contributions of the various energy sources for the period 1965–75

a Coal and oil contributions remaining unchanged at 1960 ratio

	1965	1970	1975	1965	1970	1975
	million tons of coal equivalent			percentage		
solid fuel	56·9	69·3	85·5	74·3	67·4	61·1
oil	10·4	12·6	15·5	13·7	12·2	11·1
hydro-power	1·7	2·1	2·5	2·2	2·0	1·7
nuclear	7·5	19·0	36·5	9·8	18·4	26·1
total	76·5	103·0	140·0	100	100	100

b Amount of oil used remaining at 1960 level

	1965	1970	1975	1965	1970	1975
	million tons of coal equivalent			percentage		
solid fuel	57·8	72·4	91·5	75·6	70·4	65·4
oil	9·5	9·5	9·5	12·4	9·2	6·8
hydro-power	1·7	2·1	2·5	2·2	2·0	1·7
nuclear	7·5	19·0	36·5	9·8	18·4	26·1
total	76·5	103·0	140·0	100	100	100

The first forecast in Table 3a assumes that the ratio of the contributions made by coal and oil in 1960 (5·5 : 1 in terms of coal equivalents) will continue unchanged, while the second in Table 3b assumes that the amount of oil used in power stations will remain at its 1960 level of 9·5 million tons of coal equivalent. Only time will show which is the more accurate.

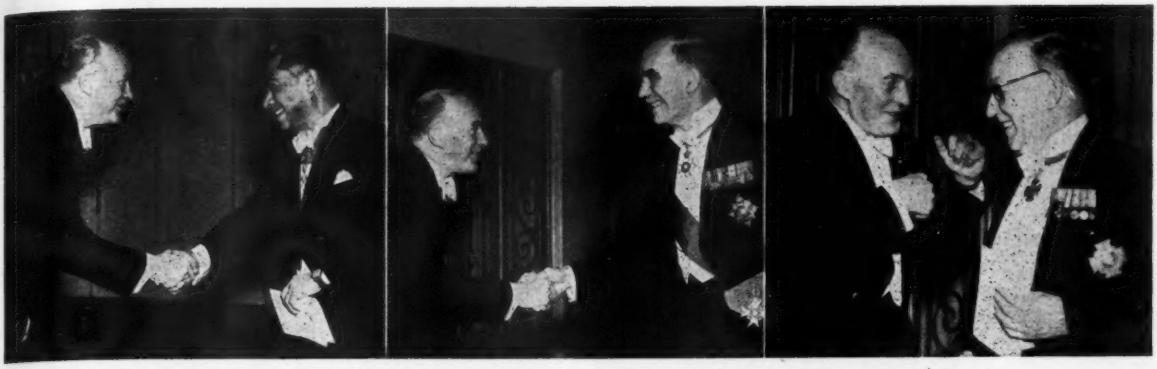
Annual Dinner of The Institution, 1961

MINISTER AND SUPPLY INDUSTRY

ABOUT 1495 members and guests were present at the Annual Dinner of The Institution at Grosvenor House, London, on Thursday, 23rd February 1961. The President, Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C.*, LL.D., B.SC., was in the chair. The following were among those present:

The Rt. Hon. Richard Wood, M.P. (*Minister of Power*); Councillor Robert L. Everest, J.P. (*The Rt. Worshipful Mayor of the City of Westminster*); The Hon. W. T. M. Beale (*Minister for Economic Affairs, American Embassy*); His Excellency Sir Edward Asafu-Adjaye (*High Commissioner for Ghana*); His Excellency Tunku Ya'acob, P.M.M., C.M.G. (*High Commissioner for the Federation of Malaya*); His Excellency Erik Braadland (*Ambassador for Norway*); His Excellency G. de Soyza, C.M.G., O.B.E. (*High Commissioner for Ceylon*); His Excellency Antonio Armendariz (*Ambassador for Mexico*); Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C. (*High Commissioner for the Federation of Rhodesia and Nyasaland*); M. I. Botha (*Acting High Commissioner for the Union of South Africa*); A. Apostol (*representing the Ambassador for France*); Denzil Freeth, M.P. (*Parliamentary Secretary, Office of the Minister for Science*); The Rt. Hon. the Viscount Falmouth; The Rt. Hon. Lord Nelson of Stafford (*Past-President; Honorary Member*); The Rt. Hon. Lord Strathclyde (*Chairman, North of Scotland Hydro-Electric Board*); Sir Noel Ashbridge, B.SC.(ENG.) (*Past-President; Honorary Member*); Sir Ben L. Barnett, K.B.E., C.B., M.C., M.A. (*Chairman, Commonwealth Telecommunications Board*); Sir Harold Bishop, C.B.E., B.SC.(ENG.) (*Past-President*); Sir Robert Cockburn, K.B.E., C.B. (*Chief Scientist, Ministry of Aviation*); Sir John Cockcroft, O.M., K.C.B., K.B.E., M.A., D.SC., PH.D., F.R.S. (*President, The Institute of Physics and The Physical Society*); Sir Harold Roxbee Cox, D.SC., PH.D. (*Chairman, National Council for Technological Awards*); The Rev. C. L. Cresswell, K.C.V.O., M.A., F.S.A. (*Chaplain of the Queen's Chapel of the Savoy; Chaplain to the Council*); Sir Josiah Eccles, C.B.E., D.SC., M.M. (*Past-President*); Sir Howard Florey, F.R.S. (*President, Royal Society*); Sir Archibald J. Gill (*Past-President*); Sir John Hacking (*Past-President*); Sir Laurence Helsby, K.B.E., C.B. (*Permanent Secretary, Ministry of Labour*); Sir Edwin Herbert, K.B.E., LL.D. (*President, British Electrical Development Association*); Sir Christopher Hinton, K.B.E., F.R.S. (*Chairman, Central Electricity Generating Board*); Sir Willis Jackson, D.SC., D.ENG., LL.D., F.R.S. (*Immediate Past-President; President, Association of Supervising Electrical Engineers*); Sir David L. Keir, M.A., LL.D., D.C.L. (*Master of Balliol College, Oxford; Chairman, Council for Overseas Colleges of Arts, Science and Technology*); Sir Robertson King, K.B.E. (*Chairman, Electricity Council*); Sir John G. Lang, G.C.B., M.B.E. (*Permanent Secretary, Admiralty*); Sir Patrick Linstead, C.B.E., D.SC., F.R.S. (*Rector, Imperial College of Science and Technology*); Sir Roger Makins, G.C.B., G.C.M.G. (*Chairman, United Kingdom Atomic Energy Authority*); Sir Harry Melville, K.C.B., D.SC., LL.D., F.R.S. (*Secretary, Department of Scientific and Industrial Research*); Air Marshal Sir Walter Merton, K.C.B., O.B.E. (*Air Member for Supply and Organization, Air Ministry*); Sir Leonard Owen, C.B.E., M.ENG. (*Chairman, British Nuclear Energy Conference*); Sir John Pickles, B.SC. (*Chairman, South of Scotland Electricity Board; President, British Electrical Power Convention*); Sir Richard Powell, K.B.E., C.B., C.M.G. (*Permanent Secretary, Board of Trade*); Sir Dennis Proctor, K.C.B. (*Secretary, Ministry of Power*); Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.) (*Past-President*); Sir Harry Railing, D.ENG. (*Past-President; Honorary Member*); Gen. Sir Brian Robertson, Bt., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C. (*Chairman, British Transport Commission*); Sir Robert Somerville, K.C.V.O. (*Clerk of the Council, Duchy of Lancaster*); Sir Gordon Sutherland, SC.D., F.R.S. (*Director, National Physical Laboratory*); Sir Solly Zuckerman, C.B., F.R.S. (*Chief Scientific Adviser to the Minister of Defence; Chairman, Defence Research Policy Committee*); W. G. Agnew, C.V.O. (*Clerk of the Council, Privy Council*); W. K. G. Allen (*Chairman, British Electrical and Allied Manufacturers' Association*); J. R. Beard, C.B.E., M.SC. (*Past-President; Honorary Member*); C. L. Blackburn, B.A. (*Chairman, Association of Consulting Engineers*); Rear-Admiral K. R. Buckley (*Director of Engineering and Electrical Training Division, Admiralty*); Dr. W. Cawood, C.B., C.B.E., B.SC. (*Chief Scientist, War Office*); P. Chantler (*Under-Secretary, Ministry of Power*); H. S. Cheetham (*President, Institution of Gas Engineers*); A. G. Dawtry, M.B.E., T.D., LL.B. (*Town Clerk, City of Westminster*); Dr. P. Dunsheath, C.B.E., M.A., D.SC.(ENG.) (*Past-President*); Dr. I. Estermann (*Scientific Director, Office of Naval Research, American Embassy*); S. E. Goodall, M.SC.(ENG.), F.Q.M.C. (*Past-President*); K. W. C. Grand (*President, Institute of Transport*); T. G. N. Haldane, M.A. (*Past-President*); H. Hardman, C.B. (*Permanent Secretary, Ministry of Aviation*); D. T. Hicks, O.B.E., T.D., B.L. (*President, Law Society*); L. T. Hinton, B.SC.(ENG.) (*Chairman, Electronic Engineering Association*); W. K. Hutchison, C.B.E., M.A., B.SC. (*President, Institution of Chemical Engineers*); D. B. Irving, B.SC. (*Chairman, London Electricity Board*); Col. B. H. Leeson, C.B.E., T.D. (*Past-President; Honorary Member*); Dr. W. A. MacFarlane, C.B.E., B.A., B.SC. (*President, Institute of Fuel*); J. C. Moston (*Chairman, Cable Makers Association*); Dr. E. S. Moult, C.B.E., B.SC. (*President, Royal Aeronautical Society*); A. H. Mumford, O.B.E., B.SC.(ENG.) (*Vice-President; Engineer-in-Chief, Post Office*); Dr. T. H. Osgood (*Scientific Attaché, American Embassy*); G. C. Ottway (*President, Scientific Instrument Manufacturers' Association*); A. A. Part, C.B., M.B.E. (*Deputy Secretary, Ministry of Education*); H. N. Pemberton (*Chief Engineer Surveyor, Lloyd's Register of Shipping*); J. A. R. Pimlott, C.B. (*Under-Secretary, Ministry of Education*); R. N. Quirk, C.B. (*Under-Secretary, General Science Division, Office of the Minister for Science*); Maj.-Gen.

The President greets the Norwegian Ambassador and the High Commissioners for Ceylon and Ghana



The Immediate Past-President welcomes the Mexican Ambassador, Sir Brian Robertson and Sir John Cockcroft

D. A. K. Redman, O.B.E. (*Director of Electrical and Mechanical Engineering, War Office*); J. H. Melville Richards (*Vice-President, Institution of Municipal Engineers*); J. W. Ridgeway, O.B.E. (*Chairman, Radio Industry Council*); Dr. James H. Schulman (*Deputy Scientific Director, Office of Naval Research, American Embassy*); Dr. W. S. Stiles, O.B.E., F.R.S. (*President, Illuminating Engineering Society*); J. C. Thompson, C.B.E., B.SC. (*Director of Electrical Engineering, Admiralty*); C. R. Waterhouse, J.P. (*President, Electrical Contractors' Association*); Dr. H. F. Willis, C.B., M.SC. (*Chief of the Royal Naval Scientific Service, Admiralty*); and H. T. Young (*Past-President; Honorary Member*).

Grace before dinner was said by the Rev. C. L. Cresswell, Chaplain to the Council.

The Minister of Power

The Loyal Toasts, proposed by the President, having been honoured, the Rt. Hon. Richard Wood, Minister of Power, proposed the toast of The Institution in these terms:

'Electrical engineers arouse different feelings in the public mind at different times and in different circumstances. In the cosy warmth of a week-end at home after the daylight fades, when one is comfortably tucked up with a book underneath a good electric light, or in front of the television set or listening to the gramophone, electrical engineers seem capital fellows. But, if one makes demands on the circuit which it was never intended to bear, suddenly the light, the television or the gramophone disappears in darkness, and the phrases used about electrical engineers are rather less complimentary.

'In the country, where I live, away from the towns, electricity has since the 1939–45 War wrought the greatest change, and here there is a division of opinion about electrical engineers. To many they seem, and for all practical purposes are, no less than fairy-godfathers, but to others, who take an interest in what are called amenities, they appear, with their power stations, switching stations, Grids and Supergrids, to be nothing better than despoilers of the countryside, determined to ensnare us poor rustics in the tentacles of industrialism.'

His feelings towards electrical engineers were more than usually warm, because that winter, despite the maximum demand on the 13th December 1960, the highest ever known and 6% above that of the previous winter, they had so far escaped load-shedding. He understood that load-shedding provided one or two problems for electrical engineers; it certainly occasioned one or two headaches for Ministers of Power.

'The supply industry, with which I have a close connection, is well served by its engineers, who have risen to the challenge of the recent phenomenal growth in the demand for electricity. To meet this growth, in the second half of the last decade the installed capacity of generating plant increased by nearly half, and in 1960 the supply industry in England and Wales commissioned more new plant than ever before and sent out more than one-eighth more electricity than in 1959.

'At the same time the efforts of engineers secured continued improvement in the thermal efficiency of power stations, with consequent considerable savings in costs. In 1959 the output of electricity per ton of standard fuel was one-quarter greater than ten years before. Despite this welcome advance in efficiency, the amount of coal required for generation increased by 5 million tons last year, and your industry therefore gave a great uplift to the prospects for coal and much-needed relief to the anxieties of the Ministry of Power.

'There are many fields in which close co-operation between the industry and the Minister can yield good results. First, in the field of safety, the aim of the Nuclear Installations (Licensing and Insurance) Act is to ensure that the design and construction of nuclear stations provide all possible safeguards both for the people who work in the plant and for the public at large.

'Then there is the field of co-operation between the Ministry and the industry in the preservation of amenities. I have been given the responsibility of either allowing or refusing to allow the building of or addition to power stations and the construction of transmission lines above ground. In each case opportunities of hearings must be given to the public, to the local authorities and to individuals who may be affected.

'Larger power stations are being planned, and sites are becoming more difficult to find which will not only accommodate these vast structures but make it possible to provide the fuel, cooling water and other necessities that must be readily available. All of us in this room and people outside are anxious to see transmission lines out of sight underground, but we are conscious of the technical difficulties, apart from the prohibitive cost.

'Thirdly, there is the controversial subject of price policy in the supply industry. It is not my responsibility, thank goodness, to fix tariffs, but there are two reasons why no Minister of Power can pretend that the structure and levels of tariffs are no concern of his.

'The first is that, in the framework of a competitive fuel policy, the Government must be responsible for seeing that competition between the electricity and other power industries

The Minister of Power proposes the toast of The Institution

is on the basis of prices which properly reflect the real costs. The second reason is perhaps even stronger. Your industry is a great consumer of capital. It is now spending about £300 million a year, about one-sixth of our total public investment in Great Britain. I am responsible for approving the supply industry's capital-investment programmes and must satisfy myself that the investment claims are not inflated through the industry's selling at less than cost in any of its major markets.'

Mr. Wood referred to the expansion of the industry and the problems involved and went on:

'But the central problem is not the physical movement of energy from one place to another but the fact that the movement is surrounded by a host of important considerations, human, social, economic, aesthetic and so on. What has impressed me most in my contacts with the electrical industry is that none of these human, social, economic, aesthetic or other considerations escapes the attention of the electrical engineers I have met in the last year and a quarter.

'This breadth of view and clearsightedness, this realization of the part that the industry plays in this framework of human considerations, give me the greatest confidence in the future of the industry. I ask you, therefore, to rise and drink the health of The Institution of Electrical Engineers, coupled with the name of its President, Sir Hamish MacLaren.'

Sir Hamish MacLaren replies

The President, in the course of his reply, said:

'When delivering my Inaugural Address I referred to the honour which my fellow-members had conferred on me by electing me their President. Having now been in the Presidential chair for nearly half my term of office and having, therefore, a much better appreciation of what it means than was possible five months ago, I should like again to express to all fellow-members my most sincere thanks for the honour they paid me in electing me to that position.

'Electrical engineering is an art, in the application of which a revolution seems to take place every ten years. This can be measured quantitatively by the fact that the consumption of electricity in this country is doubled each decade, and qualitatively by the progress each decade in the development and application of new devices, particularly at present in electronics, and by constant improvements resulting in higher efficiencies in the generation, application and control of power.

'All this means that our Institution must be constantly and continuously adapting itself to progress. It is of the very nature of our members to have minds open to the changes necessary to keep pace with progress. It is not news to many here that we have for over two years been grappling with the problem of reshaping our specialized Sections, the better to discharge our obligations to our members and to the community that they serve.

'This is not the time or place to go into details, but it is an occasion to appeal to all for a bold and imaginative approach to this problem. The history of our Institution since its foundation in 1871 as the Society of Telegraph Engineers is one of constant changes and progress; and it should not be surprising that, at this period of our history, in view of the breathtaking advances in recent years in the electronic and other fields, we should find it desirable to make some realignment in our organization.

'Let no one think from what I have just said that we have been failing to meet our responsibilities. Our record shows the reverse; but, like all organizations, we must progress or decay. Our line of approach was explained to the Council last July, and we were given their approval to follow it. This we have been doing, and I look forward in the very near future to submitting the results of our further deliberations to the Council.

'I have referred to our organization for dealing with highly specialized aspects of electrical engineering, but we must also be aware of the need for more cohesion in the engineering profession as a whole. It seems probable that this country has the right to place more names than any other on the list of world-famous engineers, but it is regrettable that the work of the engineering profession as a whole is less well understood here than in any other industrialized country. Science, as such, is surrounded by a certain glamour which helps to attract to the ranks of scientists a stream of able young men, but in this country there is apt to be too great a time-lag in the practical application of the results of their research, and this is not unconnected with the shortage of engineers.

'What concerns us now is what we can do to improve the status of the engineering profession, to ensure that in the intense competition of present-day life we attract our share of the best talent available. Sir Willis Jackson referred to this point at last year's Dinner and expressed the hope that means would be found to achieve closer co-operation between the leading engineering institutions. Like him, I do not think that amalgamation as such should be our goal. The field of electrical engineering is so wide that, in my opinion, there is and will continue to be a need for an institution devoted exclusively to that branch of engineering.

'Having said that, I would add with emphasis that I consider that all applications of electrical engineering are so closely interlinked one with another that any attempt at fragmentation in our field must be strenuously resisted.

'There are, however, many aspects of our Institution's activities which might be more effectively handled if we had an organization to do so which could speak for engineering as a whole with one voice. This could take the form of an institution supported by the existing institutions, or a joint council of the institutions concerned. Much thought and discussion are being devoted to this matter. In the meantime, nothing but good can come from making known as widely as possible that such discussions are taking place, so that the members of all the institutions concerned may form and express their opinions on a subject of such far-reaching importance to them all.

'My own thinking on the subject takes me as far as conceiving a sort of supra-institution of engineers, membership of which would be conferred on all corporate members of the supporting institutions. Its place would be analogous to that of the Bank of England, the bankers' bank, in the banking world. I am aware, however, that not all are prepared to go so far at this stage, and we might have to begin more modestly.

'There is, however, a very real danger in a highly developed country such as ours is today that the division of labour on which our standard of life and the intense pursuit of specialized branches of science depend may encourage too early specialization in education and thus prevent each individual from developing his brains and personality to the utmost of which he is capable.

'Have we not now gone far enough in the direction of using modern production techniques to shorten the working week, and would it not be better to use some of our so-called affluence in time and money to extend the time available to prepare our future citizens for their working life? I do not suggest that in the first place we should aim at extending the normal school-leaving age beyond that necessary to ensure that no latent talent remains undiscovered and to close the gap between leaving school and attending a technical college, as is recommended in the recent White Paper on "Better opportunities in technical education". But I do suggest that we should aim at giving the 5% or so of the coming generation who are endowed with the best brains a more liberal and leisurely approach to their working life.

The President replies

'It is on that small percentage that the future of our country mostly depends. I think we are failing to develop them to the potential of which they are capable, by demanding too early specialization. The universities are not without blame in the high entry standard they demand from their candidates in the subjects selected for further study. In present circumstances a boy at a public or grammar school has to make an almost irrevocable decision between the ages of 14 and 15 regarding his future. This is far too early.

'There would be an advantage in pre-university schooling providing a broad general education up to the age of 17, followed by one year of sixth-form part-specialization. The standard reached in the specialized subjects might not be so high as at present, but this would be more than compensated for by the undergraduates having had a better and broader school education. Even if it meant spending an additional year at the university, the results would more than justify the time and effort.

'It used to be quite usual, at our most northerly university, for young men to take an arts degree before reading science or medicine; and the subsequent careers of those who did so fully justified in most cases the time thus spent. I regret to say that in the unseemly haste of the times we live in there are few who do this today, and the professions concerned and the country are the poorer for it.'

Sir Hamish concluded with a tribute to the public service rendered by the Minister's family, particularly his late father, Lord Halifax, and thanked Mr. Wood for his proposal of the toast.

The toast of the guests

Sir Willis Jackson, Immediate Past-President, in proposing the toast of the guests, said:

'It is of the greatest importance on this annual occasion, and more particularly in view of what the President has just said, when so many distinguished members of other professions have paid us the compliment of spending the evening with us, that we Chartered Electrical Engineers should give evidence that our interests and our reading are not limited and circumscribed by our own special subject.

'I attempted to do this last year by quoting from Shakespeare. This year, with the same object, I propose to quote from Thomas Bailey Aldrich, 1836–1907, who will no doubt be equally well known to most of you. If regrettably this proves not to be so, may I say that I also had not heard of him until about a week ago, and from what I found of his works in "Familiar quotations" I reached the conclusion that our acquaintance would have been of quite short duration. He had, however, this rather nice but elusive thing to say about hosts and their guests:

> "Sweet courtesy has done its most
> If you have made each guest forget
> That he himself is not the host".

May I express the hope that this happy state of affairs has been achieved in this very large gathering.

'I am sure that you would wish me to express our gratitude to our principal guest, the Rt. Hon. Richard Wood, for paying us the compliment of being with us this evening. I should like, Mr. Minister, to supplement what our President has said by wishing you well in all your difficult undertakings, and to associate with this our congratulations to Mr. Denzil Freeth on his recent appointment as Parliamentary Secretary of the Office of the Minister for Science.

'Next I would say how delighted we are to have with us the first citizen of our parish, the Mayor of Westminster. We thank him for joining us. Our guests include also their Excellencies the Ambassadors for Norway and Mexico. The Polish Ambassador was also to have been with us, but

unfortunately he has influenza and cannot come. I have an additional reason for regretting this, because I want to refer later to each of these three countries. We also have as our guests their Excellencies the High Commissioners for Ghana, the Federation of Malaya, Ceylon, the Union of South Africa and the Federation of Rhodesia and Nyasaland, and their presence gives us very considerable pleasure.

'We have with us a very fulsome pride of permanent secretaries and other senior members of the Civil Service, supplemented by a number of their sparring partners from the Defence Services; and they in turn are supplemented by a number of contemporaries from the public services. These are men who carry a heavy and increasing responsibility for the proper and efficient conduct of our public affairs, and we are complimented indeed that they have accepted our invitation to be here this evening.

'If I may now enter a quieter but not a quiescent domain, we have with us several eminent members of the Church, the law and education and, coming a little nearer home, many of our close friends and colleagues representing a wide range of scientific and technological societies and institutions. We are very pleased that they have joined us this evening.

'Of these institution representatives I should like to mention two. The first is Sir John Cockcroft, because I am sure you would wish me on your behalf to congratulate him most heartily on the award to him by the United States of the "Atoms for Peace" prize and also on his election to be the first President of The Institute of Physics and The Physical Society, the arrival of which we greatly welcome. The other is the President of the Association of Supervising Electrical Engineers. I mention him not because he has any special merit individually but because it is rather unusual, and if I may say so rather nice, to have the opportunity and indeed the obligation to propose my own good health.

'I now come to our Ambassador friends from Poland, Norway and Mexico, to whom I would refer in that order, because I had the privilege last year of visiting each of these three countries. In the early months of 1960 Mr. Brasher and I paid a visit to Poland at the invitation of the Minister of Higher Education, Mr. Golanski, to have discussions on engineering education and with their engineering institution. We welcomed greatly the opportunity this evening, which unfortunately is denied us, of expressing our thanks to the Ambassador for the magnificent hospitality which we received on that occasion.

'I think you will be gratified to know that, arising out of our visit, there is to be held on the 21st and 22nd March in Warsaw a conference at which ten papers will be read by British authors on recent developments in telecommunication and traction. This has given considerable satisfaction to the Polish Institution of Electrical Engineers.

'Coming now to Norway, where my family and I spent our summer holiday, I would tell his Excellency the Norwegian Ambassador that his country is the most beautiful and the most hair-raising in which I have yet driven a car. I hope that my few remarks will encourage all my colleagues to follow in our tracks.

'Next I had the opportunity, with my wife, to visit Mexico in October, to give a few lectures—and to do a few other things. For example, at a time when the rain was pretty continuous in England my wife and I were suffering the rigours and hardships of such delightful places as Acapulco on the Pacific coast. One of the high spots was the new university campus in Mexico City, a campus which I was told accommodates something like 60 000 students. I had two outstanding impressions of this campus. The first was the unusual and courageous architecture of the buildings, and the second the exuberance and vitality of the rector, who told me that he was the first rector in the 400 years of the university's history to have been elected for a second period of office of four years.

'In conclusion I come to the second of our principal guests, the Hon. Wilson Beale, Minister for Economic Affairs at the American Embassy in London.

'It gives us great pleasure, Mr. Beale, that you have come to join us this evening, and I shall in a moment associate your name with the toast to all our guests. Before doing so, however, I should like to ask members to have a special thought when they rise for two close colleagues of ours who have been prevented from being here this evening because they are touring abroad or about to do so on behalf of our three institutions. I refer to the Presidents of the Institutions of Civil and Mechanical Engineers. Sir Herbert Manzoni has already left for a tour of the New World in the West Indies and South America, and Prof. Owen Saunders leaves tomorrow for the Far East. I am sure that we shall all wish them God-speed.

'I ask all the members of our Institution to rise and drink with me the health of our guests, coupled with the name of the Economic Minister of the American Embassy in London, the Hon. Wilson Beale.'

Mr. Beale's response

The Hon. Wilson T. M. Beale, in the course of his response, said:

'It is fortunate that you do not require all your speakers to demonstrate their expert knowledge of electrical engineering. Some of my regrettably limited knowledge of the British electrical industry was developed during a recent tour of duty in Washington, where I was subjected to pressure from your

The Hon. Wilson Beale speaks for the guests

able diplomatic representatives who wanted to be sure that British electrical equipment would be used in the construction of certain dams in the United States. During the process I also learned more about the geography of my country—for example, the location of the Big Bend dam and the Table Rock dam. As a matter of fact, the British electrical industry will always be associated in my mind with American Indians, and specifically with Chief Joseph.

'It has been my experience that a gracious host usually allows a guest to introduce at least one topic of conversation during the course of the evening. Our hosts tonight are especially gracious, and therefore I propose to exercise my privilege by talking to you on a subject of particular interest to me: the economic situation in the United States, what the new Administration is doing about it, and certain conclusions that can be drawn from developments during the brief period since President Kennedy was inaugurated,

'On the domestic side, the performance of our economy has been described, in a somewhat uncharacteristic understatement, as "unsatisfactory". The rate of economic growth has slowed down; business investment has declined; profits have not reached their predicted levels; construction activity has fallen off; car inventories have built up; unemployment has risen. On the other hand, the gross national product in the United States increased from $482 billion in 1959 to $503 billion in 1960.

'During the last month President Kennedy has advocated a number of measures for dealing with these problems. He has asked Congress to enact a temporary programme to take care of those unemployed who have exhausted their benefits. He has requested legislation to strengthen our unemployment-insurance system. More surplus food is being distributed to the unemployed, and aid is being sought for their needy children. Proposals have been put forward for the improvement of social security benefits. The President has also urged Congress to enact legislation for the redevelopment of distressed areas. Steps are being taken to improve the machinery for directing Federal contracts to firms located in labour-surplus areas, and so on.

'Other measures have been proposed which have as their objective the promotion of economic growth and price stability. These programmes provide for special tax incentives for investment in plant and equipment, for investment in human resources by strengthening education, health research and training activities, and for increased investment in natural resources. Finally, on the domestic side, the President has established an Advisory Committee on Labour–Management Policy. The members of this Committee will be drawn from labour, management and the public.

'These measures, aimed at reviving the domestic economy, are supplemented by a programme designed to deal with the international aspects of our economic position. For the past decade our international payments have been in excess of our receipts in every year except 1957. From 1951 to 1957 the deficit averaged about $1 billion annually. In 1958–60, however, the deficit has ranged between 3½ and almost 4 billion dollars. What is more, our deficit last year existed in spite of the fact that our exports of goods and services exceeded our imports by $3 billion.

'In the next few years you can expect to see a determined effort on our part to expand American exports, to attract foreign investment and to persuade more tourists to visit the United States. Steps will be taken to curb tax and Customs loopholes that encourage undue spending of private dollars abroad. Efforts will be made through the O.E.C.D. and by other means to provide for the common defence and expansion of aid to the less developed countries.

'The developments which I have outlined lead to two simple but important conclusions. The first is that the domestic and international problems confronting the new adminstration are both complex and interconnected. My second conclusion is that international co-operation is essential if these complex and interconnected problems are to be handled effectively.

'In drawing this picture for you of the problems confronting the United States today, it is not my intention to paint only in dark colours. Our President has said that our situation is one that justifies concern but not panic. The thought I would leave with you is that, while we might be able to solve our problems temporarily by acting unilaterally, we do not intend to follow that course of action; rather we propose to adopt measures which will benefit all and to seek our objectives through co-operative means.

'During the past year I have come to admire many of your ceremonies, and not least that in which I am privileged to play a part this evening. I assume that at some distant date in the past the guests at a large dinner first joined together and designated one of their number whose job it would be to remain sufficiently abstemious to be able to deliver a speech on their behalf. As their representative tonight, I know that I express their sentiments when I say that we have all greatly enjoyed the good food, good wine and good company. I thank you sincerely for a most enjoyable evening.'

O.E.E.C. ENERGY POLICY

THE Council of the Organization for European Economic Co-operation have adopted a recommendation designed to help each member country formulate its energy policy. The recommendation takes into consideration each country's own national interests, legislation, economic structure and development requirements, but also the needs of the O.E.E.C. area as a whole.

It suggests that long-term policy should be based on the assumption that there will not be any lasting shortage of energy supply in Western Europe before 1975. Plentiful supplies of low-cost energy should be sought, but the consumer should be given the greatest possible freedom of choice.

Increased exploitation of indigenous energy resources is advocated, provided that it is economically practicable. Governments should permit a more flexible price policy for coal. Better methods of marketing energy should be encouraged and the transformation of coal into secondary forms of energy stressed. Shortages and surpluses should be adjusted by measures designed to have the least possible effect on the economics of energy consumption.

The recommendation finally calls for increased co-operation and consultation among member nations and with other international organizations.

Telephone calls while flying

THE British Post Office's h.f. long-range radiotelephone service from ships at sea has been extended to include telephone calls from aircraft.

The service is available to any airline or privately owned aircraft, subject to satisfactory tests; the charges will depend on the position of the aircraft. Some European countries and an American company already offer a similar service.

LETTERS TO THE EDITOR

The nature of synchronous reactance of a cylindrical-rotor alternator .....O. E. Mainer, M.SC.(TECH.), MEMBER
Electrical engineering in the Royal Navy....C. M. R. Balbi, MEMBER
Digital representation .....H. Young, GRADUATE

THE NATURE OF SYNCHRONOUS REACTANCE OF A CYLINDRICAL-ROTOR ALTERNATOR

Dear Sir—This letter seeks to show that synchronous reactance is the sum of leakage reactance and magnetizing reactance and ought therefore to be regarded as a physical quantity and not a fiction.

The stator magnetization curve representing the relation between the stator phase e.m.f. E and the stator magnetizing current I_m may be determined and plotted as shown in Fig. 1. On dividing E by I_m the magnetizing reactance X_m is obtained. It has the constant unsaturated value X_{mu} along the air-gap line and decreases with saturation.

To a different scale the field current I_f has been added to Fig. 1 so that the curve also represents the normal d.c. magnetization curve of the alternator.

The vector diagram of the fully loaded alternator operating at lagging power factor is shown in Fig. 2. The internal e.m.f. E_1 is the vector sum of the terminal voltage V and the leakage impedance drop. To this load-vector diagram has been added the m.m.f. diagram. The effective m.m.f. F_{e1} produces the gap flux Φ_1 and e.m.f. E_1. This m.m.f. has components F_{f1} and F_{a1} representing the field and armature m.m.f.s.

Now, Φ_1 can be regarded as composed of components Φ_{f1} and Φ_{a1}. These are fictitious components of gap flux, which would be produced if the degree of saturation represented by the line through E_1 in Fig. 1 could be maintained when exciting the machine only with the field m.m.f. F_{f1}, or only with the armature m.m.f. F_{a1}. It follows that the m.m.f. triangle represents to an appropriate scale the flux triangle for this saturation line. Corresponding to this flux triangle, a similar e.m.f. triangle is obtained in which E_{f1} is the fictitious e.m.f. due to Φ_{f1} and E_{a1} that due to Φ_{a1}. Numerically, $E_{a1} = IX_{m1}$, where X_{m1} is a measurable physical quantity.

Similarly $$E_{f1} = V + IZ_{t1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

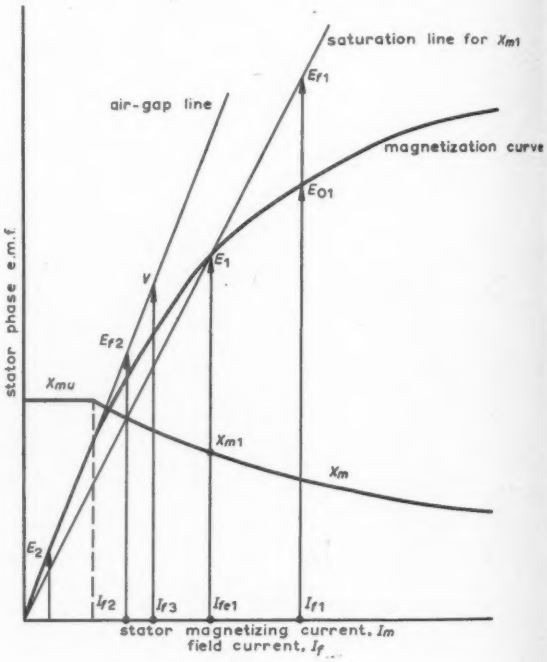
where $$Z_{t1} = \sqrt{[R^2 + (X + X_{m1})^2]}$$

If we divide the m.m.f. triangle by the field turns per pole, it represents to yet another scale the field current I_{f1}, the field equivalent of armature reaction I_{fa1}, and the effective field current I_{fe1} which sets up the gap flux. The currents I_{f1} and I_{fe1} correspond to e.m.f.s E_{f1} and E_1 on the X_{m1} saturation line, as shown in Fig. 1.

Next consider the alternator short-circuited and excited by a field current I_{f2} so adjusted as to circulate the full-load current. The internal e.m.f. E_2 equals the full-load leakage impedance drop and is a small e.m.f. well down on the air-gap line in Fig. 1, so that the magnetizing reactance is X_{mu}. From eqn. (1) it follows that $E_{f2} = IZ_{tu}$ where $Z_{tu} = \sqrt{[R^2 + (X + X_{mu})^2]}$. Both E_{f2} and I_{f2} are shown in Fig. 1.

Corresponding to rated voltage V on the air-gap line, it is necessary to make the field current equal I_{f3}, and it is apparent from Fig. 1 that:

$$\frac{I_{f2}}{I_{f3}} = \frac{E_{f2}}{V} = \frac{I\sqrt{[R^2 + (X + X_{mu})^2]}}{V}$$



1 *Magnetization curve*

This ratio corresponds to the standard definition of synchronous impedance (B.S. 205 : 1943: item 2918A). Clearly the per-unit value of unsaturated synchronous impedance is

meant, so that unsaturated synchronous reactance is given by $X_{su} = X + X_{mu}$.

Although there appears to be no British Standard definition of saturated synchronous reactance, it is obviously logical to define this as $X_s = X + X_m$, i.e. the sum of leakage reactance and saturated magnetizing reactance, in which case:

$$E_f = V + IZ_s \quad . \quad . \quad . \quad . \quad . \quad . \quad (1A)$$

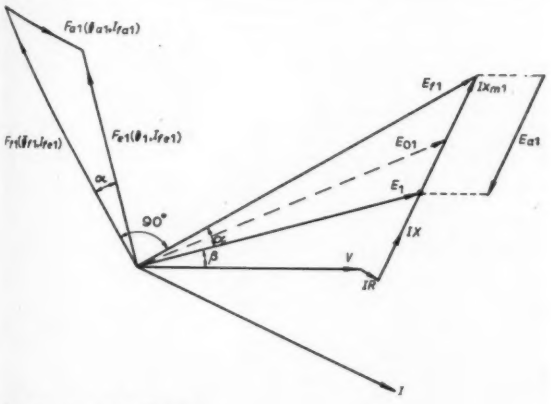
where the saturated synchronous impedance Z_s has the same meaning as Z_t in eqn. (1).

On the other hand, in the synchronous-impedance method of determining voltage regulation it is the open-circuit voltage which is taken to equal the vector sum of the terminal voltage and the synchronous impedance drop:

$$E_0 = V + IZ_s \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The open-circuit e.m.f. E_{01} obtained from the magnetization curve in Fig. 1 is shown by the broken-line vector in Fig. 2. As this e.m.f. and the internal-load e.m.f. E_1 correspond to different degrees of saturation, any value of synchronous impedance satisfying eqn. (2) must contain a fictitious component of magnetizing reactance.

The power angle (angle of deviation of the rotor) can be measured stroboscopically and shown to equal $\alpha + \beta$, i.e. the angle between E_{f1} and V. On the other hand, the angle between E_{01} and V is quite meaningless.



2 *Load-vector diagram*

For the reasons set out in the above two paragraphs, it is clear that there is no theoretical foundation for eqn. (2), so that it would be quite wrong to say that synchronous reactance must be fictitious in order to satisfy that equation.

It is hoped that this letter will stimulate your readers to wonder whether textbooks should continue to brand synchronous reactance as a fictitious quantity.—Yours faithfully,

O. E. MAINER

Electrical Engineering Branch
Royal Military College of Science
Shrivenham, Swindon, Wilts.

13th February 1961

ELECTRICAL ENGINEERING IN THE ROYAL NAVY

Dear Sir—I do not know if the letter from Lt. Q. C. A. Craufurd, set out below and its acknowledgment from his Commanding Officer still exist in Admiralty records, but they serve to illustrate yet another example of the pioneer work carried out by officers of the Royal Navy at the time referred to by the President in his Presidential Address (January 1961 *Journal*, p. 2).

H.M.S. *Andromeda*,
at Chatham,
6th February 1907

Sir,

I have the honour to bring to your notice that I have succeeded in transmitting speech and musical sounds by wireless telegraphy today between H.M.S. *Argonaut* and H.M.S. *Andromeda*. I submit that in view of the possibility of this system of wireless telephony becoming of real practical value in course of time, it would be well to record the fact that this system was invented independently by myself, and was actually made use of in the British Navy on the date in question.

I have the honour to be
Sir,
Your obedient servant,
Quentin C. A. Craufurd
(Lieutenant R.N.)

Captain H. H. Stileman, R.N.
H.M.S. *Andromeda*,
Chatham

Enclosure in Nore letter no. 298/512 of the 11th February 1907

H.M.S. *Andromeda*,
at Chatham,
7th February 1907

Sir,

I have the honour to forward the enclosed report from Lieutenant Quentin C. A. Craufurd, Torpedo Lieutenant of H.M. Ship under my command, and to inform you that I have listened to the tunes of 'God save the King' and 'Trafalgar's Bay' which were received in clear and unmistakeable tones in the ordinary receiver, these tunes having been sung into the transmitter by a man on board H.M.S. *Argonaut*. I submit that the Commander-in-Chief be moved to acquaint their Lordships with Lieutenant Craufurd's discovery.

I have the honour to be
Sir,
Your obedient servant,
Harry H. Stileman
(Captain)

The Rear Admiral
Commanding Home Fleet,
Sheerness, Chatham

A description of the equipment employed was published,* and his claim that this was the first broadcast has never, so far as I know, been disputed. I have met almost every well

* CRAUFURD, Q. C. A.: 'The first broadcast concert', *The Model Engineer*, May 1925, 52, p.545

Letters to the Editor (continued)

known pioneer in this field during my life, and no one has ever referred to an anticipation. The crudity of the equipment, no doubt the very latest in the art at the time, to my mind precludes the possibility of prior use. I hate to think what the signal/noise ratio must have been like, but there is no doubt that the apparatus worked.

So much of the past lies in the minds of the older generation which is of interest to posterity and which will soon fade away beyond recall. I would therefore gladly keep a scrap-book for the benefit of The Institution if members would care to send me items of historical interest which one day could be turned into a book. This would be in line with the *Journal* series of historical articles by Mr. MacKechnie Jarvis, which has ceased for the time being, much to my regret.—Yours faithfully,

C. M. R. BALBI
16 Old Street
St. Helier
28th February 1961 Jersey, C.I.

DIGITAL REPRESENTATION

Dear Sir—May I refer to the report of the discussion on 'Digital transducers' on p.134 of the February 1961 *Journal*?

Mr. D. S. Evans's reported statement that 'Shaft digitizers giving a 132000-position resolution could be designed' gives the impression that such instruments are as yet under development and that accuracies of this order can be achieved only with difficulty. In fact, digitizers with up to 524288-position resolution are not only possible, but in quantity production, and sell for little more than the price quoted by Mr. E. J. Petherick for a 2^{10} division-per-turn digitizer. A 2^{11} division-per-turn digitizer can be bought in Britain for around £200.

The examples I have given are not moiré-fringe types, nor is the accuracy obtained by gearing, but they give a parallel 19- and 11-bit cyclic binary-code output, respectively, for a full revolution of the shaft.—Yours faithfully,

H. YOUNG
93 Leaford Crescent
28th February 1961 Watford, Herts.

Transistors and all that

ONCE again on the 16th February 1961 the Central Hall, Westminster, was the London home of the Faraday Lecture, on 'Transistors and all that'. This year's Lecturer, Mr. L. J. Davies, had already given the Lecture in Rugby, Bristol, Swansea, Manchester, Leeds and Portsmouth before coming to London; after London there remained Birmingham, Leicester, Edinburgh and Newcastle. Repeats of the Lecture had been made in several towns. Over 2200 people were present when Mr. Davies was introduced by the President; many were senior schoolchildren. It is expected that by the end of the tour more than 20000 people will have heard the Lecture.

The President pointed out that Mr. Davies was no newcomer to the Faraday Lecture, having undertaken the 1950–51 Lecture tour, when his subject had been 'Lamps and lighting'. He was director of research and education with Associated Electrical Industries (Rugby) Ltd. and had been responsible for the design of an extensive new research laboratory at Rugby, much of it planned for semiconductor work.

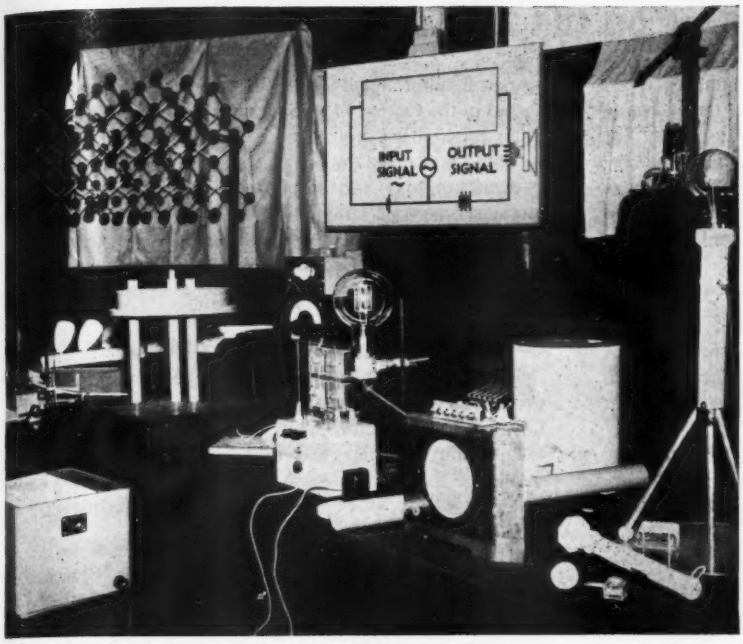
Mr. L. J. Davies demonstrates the 'lemon' oscillator

Discovery of transistors

Transistors, Mr. Davies said, although discovered only 13 years ago in the United States, were being produced at the rate of several million per year. Transistors were small, had no moving parts, no vacua, no filaments, no gas filling; they were an entirely new class of electric device. They were made from either silicon or germanium. So different was the transistor today compared with the original and so quickly did changes in transistor technology take place that it was said that if a transistor worked it was obsolete.

Transistors were now used in domestic appliances, radio receivers, etc. on the one hand and in industry in control gear etc. on the other. They promised to have universal application.

To the delight of the audience, Mr. Davies repeated what he called 'a classic experiment'. He plunged the electrodes (one of magnesium alloy, the other of copper) of a transistor oscillator into a lemon and an audible signal was produced.



View of some of the apparatus used in the demonstrations

With the help of an assistant, the Lecturer then constructed a model of a transistor about 100 times full scale. The properties of a transistor were due to its being a semiconductor. To understand these properties it was necessary to examine conductors and insulators.

Copper, aluminium, etc. were conductors because they had charges available to conduct when a voltage was applied across them. Insulators, such as glass, polythene, etc., had no spare charges and could not conduct. Once conduction started in a conductor the difficulty was to control the flow of charges; to do this one usually had to be drastic and break the circuit. Semiconductors controlled the flow of charge at least partially.

Crystal structure

How this was done could be explained by examining the crystal structure of a semiconductor. Mr. Davies had a large model of the crystal structure of silicon. Silicon was tetravalent. On introducing minute traces of impurity into the crystal the lattice structure remained unaltered but the conducting properties were improved. If a pentavalent impurity such as arsenic was introduced, there was a spare valency bond, and a free electron became available as a charge carrier (*n* type). If a trivalent impurity such as indium was introduced, a 'hole', free to capture any spare electron, was left in the lattice (*p* type). One part in 10^6 of arsenic improved the conductivity of silicon; arsenic occurred in food to the extent of 1 part in 10^6. Germanium also was tetravalent and was affected, in a similar manner to silicon, by impurities.

Impurities occurring naturally in semiconductor materials had first to be removed, and a controlled amount of impurity put in. This was done by the h.f. heating of a part of a rod of the semiconductor material. The impurities collected in the molten part of the rod, which was gradually taken along the length of the rod until the impurities were concentrated at one end. This end was removed. Impurities did not exceed 1 part in 10^9 after this treatment. Mr. Davies showed a film of the process, as well as demonstrating it with the help of an assistant.

The Lecturer then passed to uses of semiconductors. These included the generation of electric power without moving parts, the heat pump (or refrigerator) without moving parts, and rectification; while the first two applications were speculative at present, there were already wide uses of semiconductors as rectifiers. Mr. Davies described this application, using an illuminated model to show the flow of charges in a rectifier made from *p–n* material.

Another illuminated model showed the flow of charges in an *n–p–n* transistor. A film of the manufacture of transistors in the laboratory was shown; transistors in mass production had to be made in these conditions.

Applications of transistors

Mr. Davies went on to applications of transistors. Transistorization had originally meant the replacing of valves by transistors. The audience was greatly amused by the recordings used to demonstrate a transistor amplifier—one was a 'boogie', the other a string quartet—and were even more amused by the transistorized bugle. The throat microphone that the Lecturer used that evening was transistorized.

More serious applications of transistors were contactless switching, telephony, industrial control equipment and computers. A language-translation computer had between 50000 and 100000 transistors and would not be possible without them. A transistorized heart-pacemaker, which delivered 70 impulses/min to the heart, was described. This could be entirely within the patient, or the transistor and battery could be external and the impulse induced in a metal foil inside the patient.

Telemetry was a further application. A radio pill, used to determine the acidity or temperature of the stomach, internal bleeding, etc., was swallowed by Mr. R. V. Mills, Mr. Davies's chief assistant. The amplified signals from this were plainly audible to the audience.

Tribute to Faraday

In conclusion, the Lecturer paid tribute to Michael Faraday. If Faraday had been alive today, he would have been fascinated by transistors and would have made great contributions to the understanding and development of them.

The President proposed a vote of thanks to Mr. Davies which was carried, to the applause of the audience.

Institution Council meeting on the 2nd March 1961

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 2nd March 1961 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, as some items are to be the subject of further discussion by the Council.

Membership

The Council gave final confirmation to the election of those candidates whose names had been published with the January 1961 *Journal*, to become effective from the 1st March 1961. Taking these into account, the total membership at that date was 47238.

Subsistence allowances

On the recommendation of the Finance Committee, the Council approved increases in subsistence allowances paid to out-of-town members of Council and Committees attending meetings in London, designed to bring The Institution's rates more into line with the allowances paid by similar bodies.

The Institution Building

The Finance and General Purposes Committees supported a proposal of the Joint Building Committee that arrangements for floodlighting the Building at Savoy Place be put in hand. The proposed scheme involves floodlighting the building from mid-March till October, from dusk until 10.30p.m.

Massachusetts Institute of Technology—Centennial Convocation

The Institution and The Institutions of Civil, Mechanical and Chemical Engineers had received an invitation to make a joint nomination of a representative of British engineering to attend the Centennial Convocation of the M.I.T., to be held in April 1961. Since Sir Willis Jackson, D.SC., D.ENG., LL.D., F.R.S., PAST-PRESIDENT, was already attending as a personal delegate, it was agreed, with the concurrence of the three other institutions, that he should be invited to act in this capacity.

Conference of Engineering Societies of Western Europe and the U.S.A. (EUSEC)

On the recommendation of the interested Committees of the Council, it was agreed to ratify the formal Recommendations made at the 7th Plenary Assembly of EUSEC held in Brussels in 1960. The Resolutions made at the same Assembly, which related mainly to the domestic affairs of the Conference, were noted and supported.

Southern Centre—Joint Electronics and Measurement Group

The Local Centres Committee had agreed to support a request previously made by the Southern Centre Committee for permission to form a Joint Electronics and Measurement Group in the Centre. However, since the original request was made, the Centre Committee had reconsidered the matter and now felt that for the time being the appointment of conveners in Southampton, Portsmouth and any other areas where specialist meetings might be held covered the situation adequately. Meanwhile, the Council gave their sanction to the formation of a Joint Group, leaving the Centre Committee to implement the proposal when considered appropriate.

Honorary Membership and Faraday Medal

The Council unanimously adopted the recommendation of the President's Advisory Committee that the Rt. Hon. The Lord Nelson of Stafford, LL.D., D.I.C., be elected to Honorary Membership, and that the 39th Award of the Faraday Medal should be made to Julius A. Stratton, SC.D., D.ENG., LL.D., President of the Massachusetts Institute of Technology (see p. 191, March 1961 *Journal*).

Council nominations

Having conducted a ballot in accordance with the established procedure, the Council resolved on their nominations for the election of Officers of The Institution and Ordinary Members of Council to fill vacancies occurring on the 30th September 1961. Details of these nominations are given on p. 253.

LARGEST STEAM POWER STATION

THE Central Electricity Generating Board have received the consent of the Minister of Power to establish the first of the two large coal-fired power stations that they propose should be built in Nottinghamshire to burn coal from the East Midlands field.

The station now approved will be situated at West Burton, about two miles south-west of Gainsborough, and will be the most powerful steam power station in Western Europe. The generating plant will consist of four turbogenerators, each with an installed capacity of 500 MW, and four boilers, each with an evaporative capacity of 3450000 lb/h of steam.

Commissioning of the first generating unit in the West Burton station is scheduled for 1965. When complete in 1967, with a total installed capacity of 2000 MW, the station will burn about 5 million tons of low-grade coal a year, taken from the northern part of the East Midlands coalfield.

The poles still stand

ALTHOUGH more and more telephone lines are being laid underground, that familiar feature of the countryside, the telegraph pole, will be with us for a long while yet. Although their use is declining, the United Kingdom Post Office still deals with them by the hundred thousand.

In 1959–60 the Post Office Supplies Department issued 141000 poles (the highest quantity for three years). Of the poles bought by the Post Office, 17000 came from home woodlands and 46000 were imported from Scandinavia.

The articles in this regular monthly feature are based on current papers read at Institution meetings. They are written by the authors of the papers, who have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the articles bring out the main points and conclusions of the papers, their contents are not necessarily confined to the subject-matter of the original papers

Silicon power rectifiers

A Utilization Section paper (3362) with the above title by A. J. Blundell, Associate Member, A. E. Garside, B.Sc.(Eng.), Graduate, R. G. Hibberd, B.Sc., Associate Member, and I. Williams, B.Sc., Associate Member, was read before an Ordinary Meeting on the 2nd February 1961 at Savoy Place (see p. 257). This short account is based on the paper, which was published individually in November 1960 and will be republished in Part A of the Proceedings. Messrs. Blundell, Garside and Williams are with Associated Electrical Industries Ltd. Mr. Hibberd was formerly with Associated Electrical Industries Ltd. and is now with Texas Instruments Ltd.

In the field of solid-state electronics, the monocrystalline-semiconductor power rectifier has made a marked impression on the heavy-current industry. This is not without justification, for it has proved to be capable of handling the power needed in the largest commercial installations.

High temperature

In the early 1950s the germanium rectifier appeared, and this has been followed by the silicon rectifier, which has advantages in certain applications. It can operate at a much higher temperature: when held at 250°C it has, essentially, a similar characteristic to that of a germanium rectifier held at 75°C. It has the disadvantage of a higher forward-voltage drop, which causes a higher power loss when passing forward current.

Thus, similar performance is obtained in much higher cooling-air temperatures, or with smaller cooling fins. This is very attractive in the aircraft and traction industries, where weight restrictions and high cooling-air temperatures are encountered.

Alternatively, if the silicon rectifier is operated at moderate temperatures, a higher reverse voltage is obtained with normal cooling means, and this compromise has been made by all the important high-power-rectifier manufacturers. Usually a temperature in the range 150°–200°C is chosen, depending on the voltage requirements of the equipment designer. In this way a single silicon-rectifier cell can be rated at a voltage higher than that of any previous metal rectifier, and when connected in series can be used to advantage in such applications as electrostatic precipitation, with peak working voltage across each rectifier arm of 70kV.

Fig. 1 shows that part of a cross-section of a large silicon rectifier where the rectifying junction comes to the surface. Aluminium has been fused in from the top of the wafer and antimony-doped gold from the bottom. The *p–n* junction occurs in the silicon immediately below the aluminium.

1 *Part of a cross-section of a large silicon rectifier*

In reverse-bias conditions, a charged double layer extends from the junction into the silicon beneath. The width of the silicon is 7mils. When the reverse voltage is increased, the double layer extends across the silicon wafer and approaches the gold–antimony. If this layer is not perfect, a large field-induced current will flow, and the voltage that may be applied is limited.

High efficiency

The efficiency of the silicon rectifier is high, over 99%, and, with the exception of that of the germanium rectifier, is superior to that of all other forms of rectification in this respect.

In the majority of cases, high-power silicon rectifiers will be used in series–parallel connections, and this demands a certain uniformity of the forward and reverse characteristics of the cells. There will inevitably be a small amount of derating needed to operate the cells in parallel if the control of forward voltage is not to be unnecessarily severe, but it is usually not necessary to derate for series working. Indeed, it can often be more advantageous to operate the cells in series, owing to the reduced probability of string failure when the usual reverse-test safety factors are taken into account.

Papers read (continued)

As an example, cells with a nominal rating of 200A at a peak working voltage of 300V have been fitted in a rectifier for the main drive in a 2700hp single-phase locomotive needing a d.c. motor supply of 3200A at 960V.

A recent modification to the silicon rectifier has been made by forming an additional doped layer within the semiconductor wafer and attaching a third lead. This layer, when unbiased, prevents forward-current flow until a small trigger current is introduced into the extra layer; it then switches into a conducting state and remains so until the main current falls to zero.

This device is the solid-state analogue of the thyratron and is characterized by extremely fast switching, the very small power needed for control, and a forward-voltage drop not much larger than that of the silicon rectifier. It needs no filament supply or warming time, but has the semiconductor device's sensitivity to temperature.

Development and application

Already, controlled rectifiers are in production which have average current ratings up to 100A, and the development of larger cells is well advanced.

At present the formation of the extra layer limits the reverse voltage to a few hundred volts; much effort is being made to improve the position, and there is little doubt that the controlled rectifier will eventually have a wide field of application in power-control systems. 621.314.63

Protection of h.v. insulators

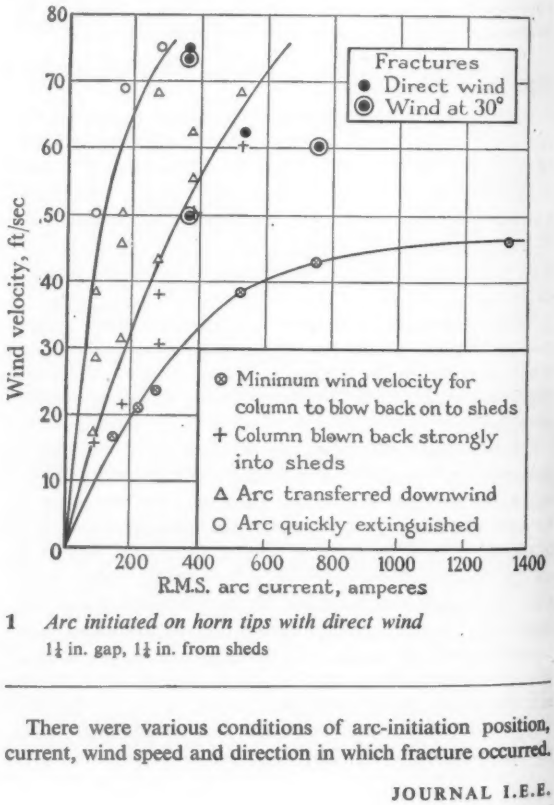
A résumé of a Supply Section paper (3289) entitled 'The protection of high-voltage insulators from power-arc damage' by A. E. Guile, Ph.D., B.Sc.(Eng.), Associate Member. The paper was published individually in July 1960 and will be republished in Part A of the Proceedings. It was read before the Section on the 1st February 1961 at Savoy Place (see p. 260). The author is in the Electrical Engineering Department, Queen Mary College, University of London, but is at present Visiting Professor in the Faculty of Engineering, University of Rangoon, Burma.

Some years ago, the problem was brought to the notice of the Electrical Research Association of the effectiveness of arcing fittings in preventing damage to insulators from power arcs. This problem arose in connection with cable sealing-ends as well as with bushings and line insulators. The E.R.A. therefore initiated an experimental investigation in the short-circuit laboratory at Queen Mary College, University of London.

After preparatory tests designed to obtain information on the relative effects of magnetic and wind forces on arcs, by means of a moderately-high-speed camera, a number of bushings were tested. These, and all the other insulators tested, were subjected to an arc of one-second duration and currents up to 1400amp. Further tests on toughened-glass test-pieces were made to show the corresponding values of arc current and duration causing fracture.

Mounted in wind tunnel

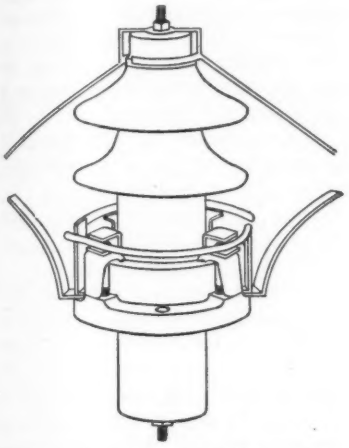
The bushings were mounted in a wind tunnel with wind speed up to 60m.p.h. Two conditions were considered, namely arcs following flashover due to (a) lightning and (b) surface deposits. These were simulated by fuse wire (a) between arcing horns or nearest metal parts and (b) across the insulator surface. With wind blowing towards an arc between horns on a small bushing, the position of the arc moved as shown in Fig. 1 when the wind speed increased, and in the middle ranges the bushing sheds were liable to be fractured.


Wind velocity, ft/sec
R.M.S. arc current, amperes
Fractures
Direct wind
Wind at 30°
Minimum wind velocity for column to blow back on to sheds
Column blown back strongly into sheds
Arc transferred downwind
Arc quickly extinguished

1 *Arc initiated on horn tips with direct wind*
1¼ in. gap, 1½ in. from sheds

There were various conditions of arc-initiation position, current, wind speed and direction in which fracture occurred.

The remedy suggested is partly the simple one of having the horn tips at a minimum safe distance from the sheds, and partly the slightly more complicated one of fitting a second pair of horns in parallel with the first on the opposite side of the bushing and connected to the first by deflector rings, as shown in Fig. 2.



2 *General arrangement with horns of modified shape*

Such modifications seem to be effective, since bushings of one type with standard horns were completely fractured 15 times in 250 tests, while after modification no fractures occurred in a similar number of tests, even though the latter series was concentrated on conditions shown to be dangerous.

With suspension insulator strings, it was found that either the line- or the earth-end unit could be damaged, with more chance of the former. Standard double-point arcing horns do not prevent damage, and a deflector ring at the line end would be an advantage.

Various types of porcelain pedestal and solid-core post insulator, and glass and porcelain pin insulators were tested. It was found for the latter that, when stirrups are bent down to form arcing horns, they should be turned further from the sheds than was recommended in B.S. 1320: 1946, and that, for complete protection, two horns at right-angles to these stirrups would be needed, as well as projections on the pins in some cases. However, operating experience shows that in Britain only about 1·5 line insulators per 100 route-miles per annum are damaged, while at special positions, e.g. transformers, tee-points, etc., the rate of damage is about 2½ times greater.

Failure of transformer bushings

Thus, although the fittings can be modified fairly simply, it would not be justifiable to change them except for special reasons. In general, transformer-bushing failures are relatively somewhat more frequent and serious, and, since they already have fittings, modification could more readily be considered.

Information from many supply authorities abroad naturally shows wide variations in experience, but in some cases the rate of damage to bushings is as much as ten times greater than in Britain, and lightning is said to be the biggest problem. It must be remembered also that flashovers due to birds and vermin make any arcing fittings unpopular. However, the paper outlines the methods by which the fittings on insulators at any voltage can be improved if desired.

621.316.932 : 621.315.62

A.C. CRANE-HOIST CONTROL

A short article based on a Utilization Section paper (3226) entitled 'A new form of crane-hoist control using a 3 : 1 pole-changing induction motor' by O. I. Butler, D.Sc., Member, and V. Ahmad, M.Sc., Ph.D., Graduate. The paper was published individually in March 1960 and will be republished in Part A of the Proceedings. It was read before the Section on the 12th January 1961 at Savoy Place, and a report appears on p. 258. Dr. Butler is Reader in Electrical Machinery at the University of Sheffield, and Dr. Ahmad is with Heavy Electrical Ltd., Bhopal, India, and was formerly at the University of Sheffield.

It appears that the first use of a.c. drives on cranes was confined to those cranes where the primary concern was a low first cost, with little regard to smooth lifting and lowering; the slip-ring induction motor with secondary-resistance control during motoring and reverse-current braking was quite adequate.

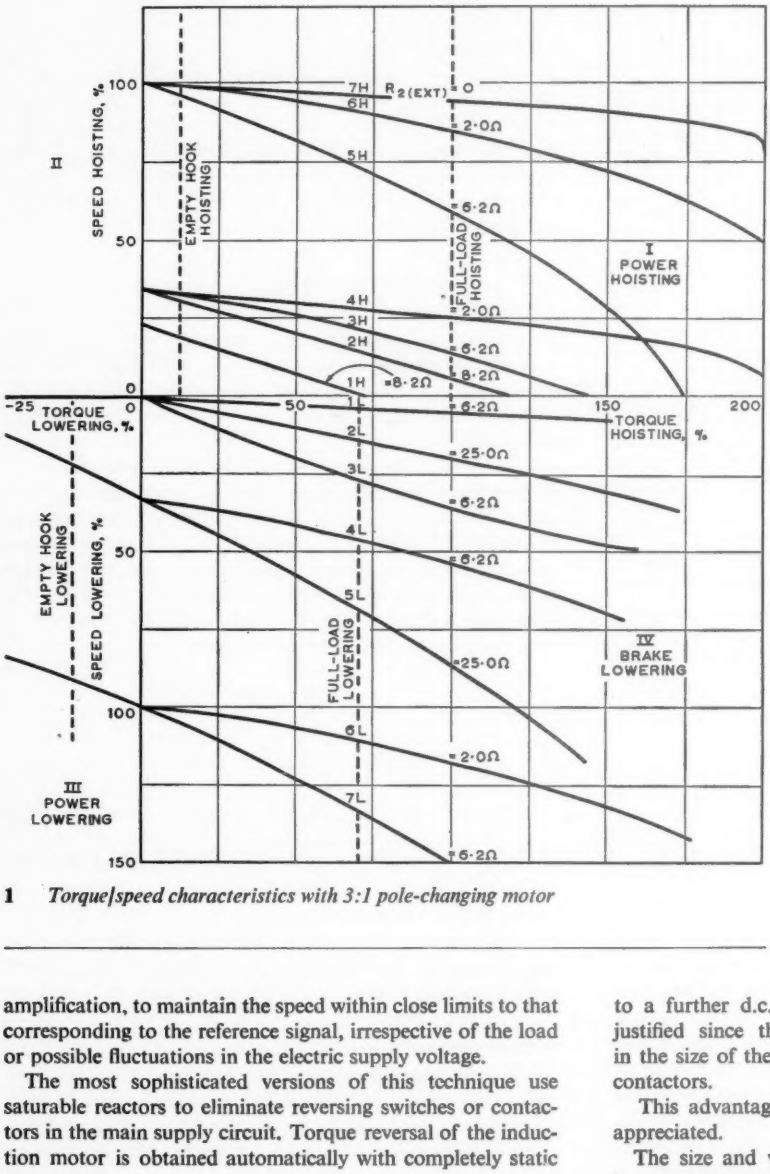
New developments

The important advantage of low first cost, compared with that of d.c. drives, has encouraged the development of both minor and major modifications to provide improved operation and increased competition with d.c. drives. The most recent developments indicate an increasing competition with even the d.c. Ward Leonard drive, which fulfils all the basic requirements of crane operation, namely smooth speed control of all loads with, in particular, rapid raising and lowering of light loads, creep speeds at all loads, and the ability to withstand brief overloads.

The most important trend in a.c. drives is the application of the closed-loop principle, in which the difference between a speed signal and a control or reference signal is used, after amplification, to maintain the speed within close limits to that corresponding to the reference signal, irrespective of the load or possible fluctuations in the electric supply voltage.

The most sophisticated versions of this technique use saturable reactors to eliminate reversing switches or contactors in the main supply circuit. Torque reversal of the induction motor is obtained automatically with completely static components.

It allows, for example, the static friction of a non-overhauling load to be overcome by 'driving down' the motor, followed immediately by any necessary raising torque to control accurately the extent of travel of the load without 'overshoot' of the desired final position.



1 *Torque/speed characteristics with 3:1 pole-changing motor*

Open-loop control

A new form of open-loop crane control, using a versatile arrangement of a 3 : 1 pole-changing slip-ring induction motor, has been investigated as a possible improvement on many of the simple a.c. drives which cater for a wide range of cranes. The versatility of the arrangement lies in its ability to readily provide d.c. and a.c. dynamic braking, regenerative braking and unbalanced-voltage hoisting, as well as the obvious advantages of a pole-changing motor.

The torque/speed characteristics of an experimental 12 : 4 pole-changing motor are shown in Fig. 1. The hoisting characteristics 1H–4H, and the lowering characteristics 1L–5L, are obtained with 12-pole operation.

The creep hoisting of 1H is obtained with unbalanced-voltage operation of the motor, while balanced voltages are used to obtain the remaining hoisting characteristics. The creep lowering of 1L and 2L are obtained with d.c. dynamic braking, while single-phase dynamic braking is used to provide the characteristic 3L.

Regenerative braking and power lowering are available on the remaining characteristics in quadrant IV, the connections of the motor being unconventional for crane hoists in that they are always made in such a way as to drive down the load.

Conclusions

Stable lowering is obtained at above and below synchronous speed without the need for reversal of the motor connections, or inclusion of protection against high transient currents during the transition to power lowering. The use of readily available a.c. dynamic braking to obtain the characteristic 3L, in preference to a further d.c. dynamic braking characteristic, is amply justified since the latter would require a 100% increase in the size of the total bank of resistors as well as additional contactors.

This advantage of a.c. dynamic braking is not generally appreciated.

The size and weight of the resistors are minimized also in consequence of the substantial reduction of the r.m.s. current taken by a pole-changing motor, and in particular a 3:1 pole-changing machine, throughout its speed range. The reduced heating of the motor circuits is of special significance for cranes requiring totally enclosed machines.

621.34.621.873:621.316.718

VACUUM AS AN INSULATOR

A short article based on a Graduate and Student Section paper with the above title by R. Hawley, B.Sc., Graduate. The paper was read in Newcastle upon Tyne on the 23rd October 1959 before the North-Eastern Graduate and Student Section, and was awarded a premium by the Council. The author is in the Department of Electrical Engineering, King's College, University of Durham.

VACUUM is finding increasing application as an insulator, for example in vacuum switches, particle accelerators, experimental fusion devices and electronic valves. Its usefulness is limited, however, by the fact that, in common with other dielectrics, it breaks down and ceases to insulate as the applied voltage is increased beyond a certain amount. The first description of a vacuum arc was given in 1897, but more recently much work on the breakdown aspect has been carried out.

The vacuum arc is observed at pressures below 10^{-4} torr. In this region, the mean free path of the molecules is large compared with system dimensions, and a charged particle drawn from one electrode to the other is unlikely to collide with residual gas molecules: thus the breakdown is no longer dependent on the pressure or nature of the intervening gas.

As the potential across a pair of plane parallel smooth-surfaced electrodes in a vacuum is increased, a small emission current may begin to flow. In certain conditions, pulses of current may arise which, since they are self-extinguishing, are called 'micro-discharges'. When the voltage is increased beyond a critical value, instability is produced and a heavy-current arc flows, this current being limited by the characteristics of the supply circuit. It is generally accepted that some mechanism takes place whereby vapour is released from the electrodes, providing sufficient elementary particles to initiate the arc.

Breakdown parameters

One difficulty in obtaining reproducible data in vacuum breakdown tests is the fact that conditioning takes place. If the gap is repeatedly broken down, the breakdown voltage gradually increases until it reaches a plateau region, where there is no apparent increase but the results obtained still vary within wide limits. Such conditioning is not necessarily permanent and may require from ten to 10000 flashovers.

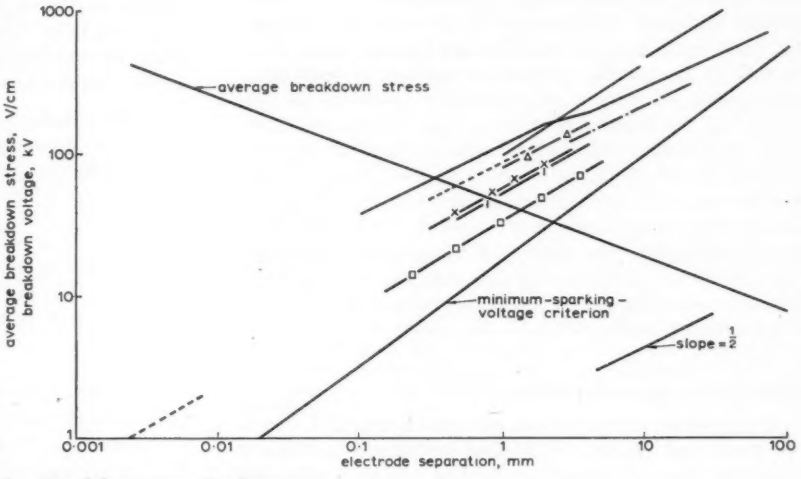
As the separation between the electrodes is increased, the sparking voltage does not increase at an equal rate, with the result that the breakdown stress falls with increased spacing.

An empirical relationship between electrode spacing and the most probable sparking voltage for spark-conditioned electrodes can be written as:

$$VE = C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where V is the total applied voltage, E the gross surface gradient, and C a constant depending on the electrode material and its surface condition.

Substituting $E = V/d$ in (1), where d = electrode separation (i.e. the case of plane parallel electrodes, neglecting any local intensification at the surface due to micro-irregularities), the relationship becomes:



1 *Breakdown strength of vacuum*

Variations for a given material are due to differences in the various investigators' experimental techniques

——— steel - - - - tungsten — · — aluminium — | — chromium
— × — copper — △ — molybdenum — □ — lead

$$V = k\sqrt{d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Thus

$$V = kd^{\alpha} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\alpha = \frac{1}{2}$.

Most experimental results, when plotted on a log-log scale, approximate to straight lines with slopes of about $\frac{1}{2}$, but this value must not be taken as exact.

The material of the electrodes affects the breakdown voltage for a given separation (Fig. 1), and certain experiments indicate that the breakdown value is proportional to the tensile strength of the anode material. The threshold voltage of the micro-discharges and the voltage at which an emission current appears in the gap are also dependent on the electrode material.

Electrode geometry seems to play a role, and, if the gap is changed from a plane parallel configuration to a point

opposite a plane, the breakdown value increases, with the maximum occurring when the point is the anode.

An investigation of the effect of electrode temperature showed that for nickel and iron electrodes the strength remained unchanged up to 500° C, thus leading to the conclusion that gases and vapours of organic compounds adsorbed on the surface of the electrodes do not substantially influence the occurrence of breakdown.

The strength is also dependent on the frequency of the applied voltage, and a given gap withstands a higher impulse than alternating level and a higher alternating than direct level. A magnetic field in the gap markedly changes the nature of the breakdown phenomenon and the degree of damage to the electrodes.

Early workers, who believed that breakdown was initiated by field emission from microscopic points on the cathode, thought that higher strengths could be obtained the smoother the cathode surface. The conditioning effect was assumed to be due to the removal of micro-projections by sparkover. There exists an amount of contradictory evidence on this point, and the position is still not clear. Direct studies of clean surfaces are complicated by oxidation and other factors.

Once the arc has been struck, it appears to move over preferential areas on the electrode, and limitation of the arc current below about 1 amp seems to prevent the formation of a stable discharge. The insertion of an insulating material in the form of a rod between the electrodes causes breakdown to take place along the surface of the rod at a lower voltage than in a simple vacuum gap.

Criterion for vacuum breakdown

In the design of high-voltage equipment, it is not so much the breakdown voltage of electrodes conditioned by multiple sparkover that is of importance but the voltage at which the first spark occurs. This is particularly true of experimental fusion devices, where it may well be impossible to condition such large structures. A criterion for minimum sparking voltage that covers a large range of surface gradients, gaps and frequencies takes the form:

$$WE^2 \exp(-K_1/E) = K_2 \quad . \quad . \quad . \quad . \quad (4)$$

where W is the maximum possible energy of a particle at the electrode surface prior to a spark, in electron volts, E is the cathode gradient, in volts per centimetre, K_1 is $1{\cdot}7 \times 10^5$ and K_2 is $1{\cdot}8 \times 10^{14}$.

Pre-breakdown conduction

Emission currents between electrodes with ultra-clean surfaces in a sealed-off vacuum occur at values of stress several magnitudes lower than those required theoretically to give appreciable field emission currents. It is not yet clear what the exact mechanism of emission is, but attempts have been made to explain it in terms of a basic field emission or a thermionic Schottky emission.

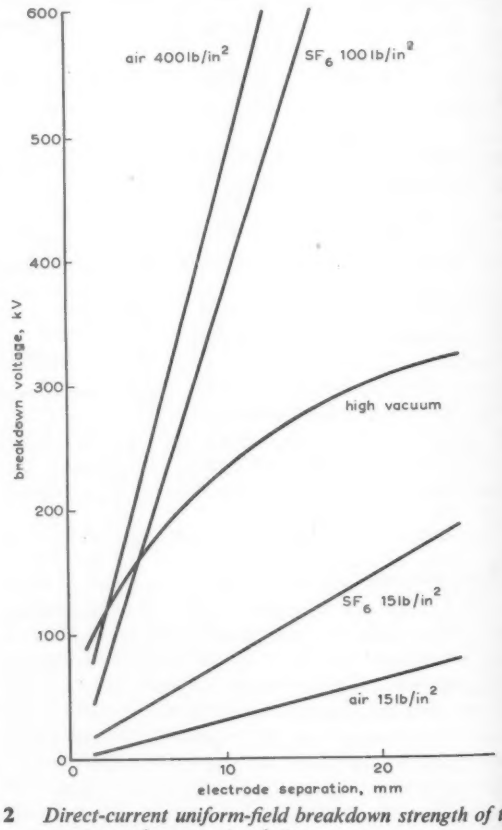
In a continuously pumped system and with un-degassed electrodes, the phenomenon of pre-breakdown appears to be different. While emission currents are again observed at low stresses, it has been noted that, in addition, cases arise where the current is not a direct function of voltage but the self-extinguishing pulses of current known as micro-discharges are produced. Such pulses have been explained in terms of a negative-ion/positive-ion exchange between the electrodes, the ions arising from a contaminating layer of hydrocarbons on the surfaces.

Vacuum-breakdown hypotheses

Hypotheses which have been put forward to explain the mechanisms of vacuum breakdown can be split into three broad classes:

(a) Those postulating an interchange of elementary particles, i.e. electrons, positive ions, etc.
(b) Those assuming surface effects at the electrodes, i.e. resistive heating of projections, evaporation of microscopic areas, instability of surface, etc.
(c) Those postulating a clump-type mechanism, i.e. an actual transfer across the gap of small amounts of electrode material.

Theories depending on the field emission of electrons would not appear to be applicable to large gap spacings, owing to the fall in stress as the gap is increased. Hypotheses



2 *Direct-current uniform-field breakdown strength of typical gaseous and vacuum insulation*

relying on the particles having sufficient energy on arriving at the electrodes to release further particles seem to fail, for measurements show that the number of particles released is too small for this type of mechanism to become cumulative.

Certain surface-effect hypotheses appear to hold for very small gaps and limiting conditions, but for large gaps and practical surfaces it seems that a clump-type mechanism is most likely. Clumps of material could be torn out of the electrodes owing to the surface stress and accelerated across the gap. The resultant vapour in which the arc forms could be due to the clumps vaporizing on impact or transferring their energy to small areas on the electrodes, causing the areas to vaporize.

Conclusions

It is important that the properties of vacuum as an insulator should be most carefully reconsidered, and if possible improved. At present it seems that the breakdown voltage of a given gap can be increased by:

(a) Changing the electrode material
(b) Conditioning
(c) Introducing a non-uniform field
(d) Increasing the frequency.

Should a way be found that enables vacuum to support the same gradients at large gap spacings as it does at the smaller, then not only will this result in a decrease in size of equipment already using vacuum insulation, but also vacuum will be able to challenge the compressed gases, which at the moment are far superior in their performance at larger spacings (Fig. 2).

A theory applicable to the whole field of vacuum breakdown and pre-breakdown effects is clearly a desirable possibility. Alternatively, hypotheses selected from those already advanced might be chosen for the particular régimes and situations for which they appear to be valid. It seems most likely that, in order to determine the exact mechanism of breakdown, surface effects at the electrodes will have to be studied as the stress is increased from zero to the breakdown value.

Once this is ascertained, methods of increasing the voltage holding of a given gap may possibly be evolved.

621.315.618.032.11

Rural electrification

A summary of a Review of Progress (paper 3518) 'The development of rural electrification' by G. F. Peirson, Member. The paper is published this month in Part A of the Proceedings. The author is with the Midlands Electricity Board.

In this monthly section are summaries of papers published in the *Proceedings* of The Institution which have not been read at Institution meetings. They are included primarily for reference. Reprints, price 2s., become available about two months after publication

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The review records the progress made in the development of rural electrification up to the present time. Reliable statistical information could be obtained only for the period since 1920, and graphs depicting farms and other rural consumers and the annual supply have been prepared accordingly.

Historical survey

The historical survey pays due recognition to the valuable pioneer work carried out by private and municipal undertakings. Considerable growth of rural load took place under their control. Further progress following the nationalization of the electricity supply industry in 1948 has been at an even greater rate.

Codes of Practice and Overhead Line Regulations which, among other things, determined the methods of construction are mentioned.

Overhead lines

The pioneers in rural electrification, often with the co-operation of the Electricity Commissioners and the British Electrical and Allied Industries Research Association, were successful in obtaining modifications, consistent with safety in service, to the Overhead Line Regulations. These modifications resulted in reduced cost of overhead-line construction. The major steps forward are noted.

The physical effect of the relaxation of the Overhead Line Regulations on conductors and wooden poles, and the fundamental changes which have taken place in the design features of m.v. and 11 kV lines, are referred to.

Overhead-line components are discussed, and special reference is made to wooden poles for lines up to 66 kV.

The service obtained from porcelain and glass insulators, and the effect of British Standard 137 on the standards of insulation, are considered. Leakage currents and associated television interference, together with the experimental work for its elimination, are discussed.

Copper and aluminium for use as overhead-line conductors are compared physically and economically, and the design of mild-span and dead-end joints is examined.

The design of air-break isolators and the advantages of interrupter head switches, which have been adopted extensively following exhaustive tests carried out by one of the Area Boards, are mentioned.

Papers published (continued)

Protective devices

A section is devoted to protective devices, and it traces the progress made in equipment of this type, especially fuses, reclosers of the weight-operated type, arc-suppression coils, and high-speed automatic circuit-reclosers. The operational experience is given of two Area Boards, both with approximately 6000 miles of 11kV rural lines, one system being protected by arc-suppression coils and the other by high-speed automatic circuit-reclosers.

The general progress which has been made, despite difficulties experienced, with the introduction of protective multiple earthing is noted.

Present-day trends

Modern trends in rural-transformer design are recorded, and a brief description is given of live-line operation as now practised in this country, which considerably reduces the number of prearranged interruptions that need to be made for work to be carried out on h.v. lines.

Outage times have also been reduced by the use of v.h.f. radiocommunication with construction gangs and repair parties, and the advantage of this means of communication over complete dependence on Post Office lines is shown.

The review concludes with a brief summary of the changes that have taken place over the years in the design of rural single- and 3-phase distribution systems. 621.316.15

Propagation of 3cm radio waves

A summary of an Electronics and Communications Section paper (3501) 'Some factors influencing 3cm radio-wave propagation oversea within and beyond the radio horizon' by F. A. Kitchen, B.Sc., A.Inst.P., Member, W. R. R. Joy, B.Sc.(Eng.), Graduate, and E. G. Richards, M.Sc. The paper will be published in Part B of the Proceedings. The authors are at the Admiralty Surface Weapons Establishment, Portsmouth.

THE results of short-term oversea measurements of the variation of received-signal level with range from a 10Gc/s transmitter are presented. The variation of signal level within the horizon was rarely that expected for propagation through an atmosphere having a uniform refractive-index gradient. Signal losses of 5–30dB frequently occurred well within the horizon, these losses being recovered when the range between transmitter and receiver was sufficiently reduced. A weli defined interference pattern usually occurred in the region of reduced signal level.

Some data on the variation of refractive index with height up to about 700ft above sea level were obtained using a radio sonde and a captive balloon, but the detail was not sufficiently fine to enable a direct relation to be established between signal losses within the horizon and the occurrence of irregularities in the refractive-index profile at low elevations.

A direct relation was found between the signal level within the horizon and that propagated well beyond the horizon into the extra-diffraction region. 621.391.812.62.029.63

THE JOURNAL DIGEST | MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monograph as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

A broadband waveguide junction containing dielectric

Monograph 437E

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D.

A METHOD is described for obtaining a broadband impedance match between two joined waveguides of differing cross-section. The method involves the use of an axially mounted dielectric which partially fills the waveguide cross-section. With an appropriate choice of dielectric cross-sectional area and permittivity, the electromagnetic field is mainly confined to the region of the rod. In these conditions the waveguide cross-section may be abruptly changed without appreciable reflection.

The case of two joined circular waveguides containing an axial dielectric rod is treated theoretically for H_{01}-mode propagation. A similar configuration is studied experimentally for the H_{11}-type mode of propagation. In both cases an appreciable reduction in reflection coefficient occurs when the rod is present. The application of the principle to other waveguide cross-sections is briefly mentioned.

Certain approaches to electromagnetic field problems pertaining to dynamo-electric machines

Monograph 438U

K. G. MUKHERJI, B.E., PH.D.

CURRENT-CARRYING circuits in electric rotating machines give rise to electromagnetic fields which are modified by surface polarities induced in adjacent ferromagnetic media and by eddy currents

induced in neighbouring conducting media. The author reviews certain approaches towards solving some of the electromagnetic problems involved and introduces a method for taking account of the reaction of eddy currents induced in a ferromagnetic medium on their inducing field.

A note on optimum linear multivariable filters

Monograph 439M

R. J. KAVANAGH, B.SC., M.A.SC., PH.D.

THE explicit solution for the optimum linear physically-realizable multivariable filter involves the factorization of a power-spectra matrix into two matrices, one having all its poles in the left-half p-plane and the other having all its poles in the right-half p-plane. No general method of accomplishing this factorization has previously been available.

The author describes a method of factorizing any power-spectra matrix in the required manner. As a result, the explicit solution for the optimum filter is obtainable in a number of cases not previously solvable without resort to implicit methods. It is always possible to obtain a physically-realizable multivariable system that will transform any given set of signals into an equal number of incoherent white-noise signals. Similarly, a physically-realizable multivariable shaping filter may always be found to transform a set of incoherent white-noise signals into an equal number of signals with any desired power-spectra matrix.

Factors affecting the behaviour of an electric arc under transient conditions

Monograph 440S

I. A. BLACK, B.SC.(ENG.), PH.D.

THE author describes an investigation into the relation between voltage and current in an arc in transient conditions. It is shown theoretically that the arc resistance is a function of the energy in the arc column, while the power loss from the arc is a function of arc resistance.

The relation between arc resistance and change of arc energy has been obtained by injecting pulses into a static arc. This relation is valid for periods from 3 μs up to at least 1 ms. The relation between power loss and arc resistance has also been derived experimentally. Measurement of the electrode voltage drop in transient conditions has enabled electrode and arc column effects to be separated.

It is shown how the relation between resistance and energy and the relation between power loss and resistance are affected by a change of arc length, initial arc current and electrode material.

Finally, the experimental results are compared with dynamic arc equations published in the literature.

An experimental proton linear accelerator using a helix structure

Monograph 441M

D. P. R. PETRIE, M.SC., R. BAILEY, B.SC., D. G. KEITH-WALKER, B.SC.(ENG.), H. LONGLEY, B.SC., *and* D. R. CHICK, D.SC.

THE authors explain the design and construction of a short experimental length of linear accelerator using a helical waveguide as the slow-wave structure to accelerate protons from 2·5 to 4 MeV.

Factors influencing the design of the helix structure are considered; these include the maximum voltage between turns which can be tolerated and the available power and frequency of the r.f. supply. The theory of a helix supported on a dielectric tube is given, and from the results are determined the variations in pitch to give the required acceleration.

The accelerator was driven by a push-pull triode oscillator operating in 6μs pulsed conditions at 300 Mc/s with a peak output of 600 kW. The oscillator and r.f. components are discussed in detail.

The beam-energy spectrum at the output of the accelerator was measured for a variety of working conditions, changes being made in beam-energy input and power and frequency of the r.f. supply. The results obtained confirm the theory and show that with certain restrictions a helix slow-wave structure of the type described provides a convenient method of proton acceleration.

THE JOURNAL DIGEST | PAPERS TO BE READ

Mechanical and manufacturing aspects of the banana-tube colour-television display system

Paper 3562E, *Part B*

H. HOWDEN

THE major mechanical components of the banana-tube colour-display system are described, together with the materials and manufacturing techniques used to achieve results consistent with the requirements of the system. Development has proceeded to a stage where a fully engineered version more suitable for quantity production could be considered.

To be read on the 15th May 1961

Appraisal of the banana-tube colour-television display system

Paper 3563E, *Part B*

K. G. FREEMAN, B.SC., *and* B. R. OVERTON, B.SC.

THE many factors which determine the potentialities and limitations of the banana-tube system as a possible solution to the colour-display problem are considered in some detail. Limitations imposed by tolerances set by the requirements of the system are stated, and an appraisal of the picture quality is made. Some indication of possible cost compared with that of other displays and an over-all appraisal and indication of future possibilities are given.

To be read on the 15th May 1961

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Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion. Reprints become available, price 2s., about two months after the appearance of the paper in the Proceedings.

Applications quoting the serial number of the paper or reprint as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Circuits for the banana-tube colour-television display system

Paper 3561E, *Part B*

K. G. FREEMAN, B.SC.

THE circuits necessary to operate the banana-tube colour-display system are described. Circuit techniques which are peculiar to this form of colour-picture display are described in some detail.

To be read on the 15th May 1961

Papers to be read (continued)

The banana-tube display system: a new approach to the display of colour-television pictures

Paper 3564E, *Part B*

P. SCHAGEN, PH.D.

AN introduction is given to the concept of colour-display systems with mechanical field-scan. The optical elements are of fundamental importance to this kind of display, and various optical aspects are discussed, including the advantages of direct-viewing systems over projection, the application of cylindrical optical elements and the size of moving optical elements in relation to the required picture size. This discussion leads to the basic concepts of a rotating mirror, or a lens drum with a magnifying cylindrical mirror.

The fundamental properties of these two solutions are compared, and the favoured system with the banana tube is described in detail. The basic requirements of this system with respect to the design of the tube, the optical elements and the mechanical components are dealt with.

Finally, some inherent advantages of the present system are discussed, and possible further improvements are mentioned.

To be read on the 15th May 1961

Colorimetry of the banana-tube colour-television display system

Paper 3565E, *Part B*

R. N. JACKSON

THE principal sources of errors in colour reproduction of the banana-tube system are the colour phosphors employed, the finite spot size of the tube and the self-decoding colour circuits. The errors due to these causes are analysed, particular attention being paid to the use of an incorrect green primary phosphor and to methods of evaluating the importance of random errors in the chromaticity and luminance of the phosphors. Methods of alleviating errors due to the incorrect green primary by special correction circuits are discussed.

To be read on the 15th May 1961

Development of the banana tube

Paper 3566E, *Part B*

B. A. EASTWELL, B.SC., *and* P. SCHAGEN, PH.D.

THE unconventional system of beam deflection and spot formation in the banana tube is examined in detail. The discussion of electron optics includes a formulation of the requirements for the permanent-magnet deflecting field, as well as a detailed description of the effect of this field on the electron spot, in conjunction with the scanning and focusing means employed.

The tube technology is considered in broad outline, including certain aspects of tube manufacture.

To be read on the 15th May 1961

The corona discharge and its application to voltage stabilization

Paper 3174E, *Part B*

E. COHEN *and* R. O. JENKINS, PH.D.

THE properties of a gas discharge which make it suitable for voltage stabilization are discussed. Various types of corona discharge are described, and it is shown that a corona discharge between a wire anode mounted axially in a cylindrical cathode is the most suitable for voltage stabilization. To obtain the required low impedance it is necessary to use hydrogen as the filling gas.

The effect of dimensions on the voltage and impedance of the discharge is discussed, and characteristics of various tubes that have been developed as corona voltage stabilizers covering a range of 350–7000 V are shown. Finally, some of the applications of such tubes and their appropriate operating conditions are given.

To be read on the 8th May 1961. This paper was originally published in the May 1960 Proceedings, 107B, p. 285

Impedance/frequency characteristics of glow-discharge reference tubes

Paper 3175E, *Part B*

F. A. BENSON, D.ENG., PH.D., *and* P. M. CHALMERS, B.ENG.

THE impedance/frequency characteristics of some cold-cathode glow-discharge tubes over the frequency range 300c/s–5 Mc/s have been obtained. The results are shown to agree with an extended form of a theory by van Geel.

Impedance measurements indicate that there are several delayed effects in the glow discharge which affect the l.f. impedance characteristics considerably. Tentative suggestions about the origin of these effects are discussed, and the influence of some tube parameters on the magnitudes of the consequent delay times are indicated. The equivalent circuit of the glow-discharge tube is determined from the results.

To be read on the 8th May 1961. This paper was originally published in the March 1960 Proceedings, 107B, p. 199

THE JOURNAL DIGEST | IN THE PROCEEDINGS

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (APRIL 1961)

W. ABBOTT, C.M.G., O.B.E., PH.D., B.SC. PAPER 3358, OCTOBER 1960 **The training of oversea graduate engineers with particular reference to the F.B.I. scholarships scheme** *January 1961*

Sub-Centre and Group Chairmen's Addresses

PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., E. R. LAITHWAITE, M.SC., PH.D., J. F. EASTHAM, M.SC., *and* L. S. PIGGOTT, M.SC. PAPER 3149U, FEBRUARY 1960 **The logmotor—a cylindrical brushless variable-speed induction motor** *November 1959*

PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., E. R. LAITHWAITE, M.SC., PH.D., J. F. EASTHAM, M.SC., *and* W. FARRER, M.SC. PAPER 3262U, MAY 1960 **Brushless variable-speed induction motors using phase-shift control** *January 1961*

G. F. PEIRSON. PAPER 3518 **The development of rural electrification** (Review of progress) *April 1961*

E. H. COX *and* R. E. MARTIN, D.F.H. PAPER 3290S, JULY 1960 **Radio-communication in the power industry** *January 1961*

J. RAVENSCROFT, B.SC. PAPER 3328U, SEPTEMBER 1960 **The determination of the electrical characteristics of an arc furnace** *March 1961*

W. R. STEVENS, B.SC., *and* H. M. FERGUSON. PAPER 3260U, MAY 1960 **A survey of street lighting and its future** *February 1961*

Discussion on **Turbogenerator performance under exceptional operating conditions** before the North Midland Centre, the South Midland Supply and Utilization Group and the North-Western Supply Group

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MARCH 1961)

See the Journal for March 1961, p. 179

PART C. MONOGRAPHS (MARCH 1961)

See the Journal for March 1961, p. 179

OBITUARY

PERCY MAYSON BENNETT

Percy Mayson Bennett who was born on the 18th August 1875 died on the 15th November 1960. He was educated at Hulme Grammar School and at Owens College, Manchester, and apprenticed to Royce's, Manchester, studying part-time at Manchester Technical School.

In 1897 he joined John Holroyds as shop foreman and in 1898 transferred in the same position to C. A. Parsons at the time of the *Turbinia*. He became an engineer with Callender's Cable Co. in 1901 and was sent to South America as an agent for the company in 1902, subsequently spending 12 years in Mexico on Government and public-utility contracts and in 1904 becoming manager and director of P. M. Bennett and Co.

During the 1914–18 War he was with the Ministry of Munitions, after which he was engaged for some years in Chile with Whitehall Securities Corporation and Callender's Cables. He later returned to England to work on the early stages of the Grid scheme. He was then concerned with the Athens undertaking for a number of years, until the outbreak of the Second World War when he joined the Ministry of Supply and was appointed construction engineer for the Royal Ordnance Factories. He retired in 1944.

He was popular with all who came in contact with him in business. He was a keen sportsman and an enthusiastic clubman, being one of the founder members of the Prince of Wales Club, Santiago. He is survived by his widow, two daughters and two sons.

He joined The Institution as an Associate Member in 1901 and was elected a Member in 1910.

JOHN COSSAR FORSYTH

Lt.-Col. John Cossar Forsyth, B.SC.(ENG.), a former engineer-manager of the Christchurch Municipal Electricity Department who was well known throughout New Zealand as an electrical engineer, died at his home in Christchurch on the 24th October 1960. He was born at Auckland on the 11th May 1890 and was educated at Mt. Eden Public and at Onehunga District High Schools. After serving an apprenticeship with A. J. Parker and Co., Auckland, he received his engineering education at the Royal Technical College, Glasgow, where he gained the associateship of the college and the degree of B.Sc.(Eng.) of the university. While in Scotland he acquired practical experience with Bruce Peebles, Edinburgh, as a test engineer in 1914 and again in 1919.

When he returned to New Zealand in 1920 he joined Christchurch Municipal Electricity Department as an assistant electrical engineer. Five years later he was appointed chief electrical engineer and in 1949 became engineer-manager, retiring from that position in 1955.

He was a past-president of the New Zealand Electricity Supply Authorities' Engineers' Institute, a past-president of the New Zealand Institution of Engineers, and a fellow of the Illuminating Engineering Society, London. He received the award of the New Zealand Institution of Engineers Fulton Gold Medal in 1935. He was formerly chairman of the Illuminations Committee and a member of the Welding Committee of the Standards Institute. He was the author of a number of technical papers.

In the 1914–18 War he served in France with the Royal Field Artillery (Territorial Force), attaining the rank of major and being mentioned in dispatches. In the Second World War he served in the Royal New Zealand Artillery in charge of the anti-aircraft defences of Christchurch, retiring from the Army as a lieutenant-colonel.

He is survived by his widow and two sons.

He joined The Institution as a Graduate in 1919 and was elected an Associate Member in 1923 and a Member in 1931. He served on the New Zealand Oversea Committee from 1949 to 1960.

G. H. B.

RAYMUND GEORGE HART

Air Marshal Sir Raymund George Hart, K.B.E., C.B., M.C., R.A.F., who was born on the 28th February 1899 was accidentally killed on the 16th July 1960. He was educated at Simon Langdon School, Canterbury, and at the Imperial College of Science and Technology. He joined the Royal Flying Corps in the 1914–1918 War and was awarded the Military Cross as a member of 15 Squadron in one of their combat victories.

After being on the unemployed list from 1919 to 1926, during which time he attended Imperial College and had some experience in industry, he rejoined the Royal Air Force and was granted a permanent commission in 1929.

In 1936 he began his long association with radar, joining Sir Robert Watson-Watt's team at Bawdsey Research Station. He represented the Service needs at the vital early stage of the development and subsequently undertook the training of the first operations and maintenance personnel. Two years before the outbreak of war he was moved to Headquarters, Fighter Command, as chief radar officer and worked on the reporting system and filter room.

During the war he became successively deputy director of radar at the Air Ministry, chief signals officer at Fighter Command, a member of the Allied Expeditionary Air Force, and finally chief air signals officer at Supreme Headquarters, A.E.F., Versailles. His subsequent appointments included air officer commanding, Signals Training Group, Gloucester; director, technical policy, Air Ministry; air officer commanding, 90 (Signals) Group; director-general, engineering, Air Ministry; and finally in 1956 controller of engineering and equipment, Air Ministry. On retirement in 1958 he followed Vice-Admiral J. W. S. Dorling as director of the Radio Industry Council.

As a trained engineer he applied his talents whole-heartedly to the Royal Air Force. He showed wisdom and judgment and had the ability to mould into a coherent whole a team of diverse views. He laid the foundations of radar in the Royal Air Force; his full contribution was appropriately recognized by his final appointment to the premier technical responsibility in the Air Ministry. Had his career not been so tragically terminated, the radio industry would have greatly benefited from his broad knowledge and experience.

He joined The Institution as an Associate Member in 1948 and was elected a Member in 1954. He was appointed a Knight Commander of the Bath in 1957.

F. S. B.

ALEXANDER KELSO

Alexander Kelso who died on the 28th November 1960 was born in Fife, Scotland, on the 16th April 1898. He was a native of Fife, Scotland, and was educated at Foulford Public and at Beath Higher Grade Schools, Cowdenbeath. He was apprenticed to Lochgelly Iron and Coal Co., studying part-time at Fife Mining School and at Heriot–Watt College, Edinburgh. He served in the 1914–18 War as a pilot with the Royal Flying Corps and in 1920 joined Fife Electric Power Co., Dunfermline, where he attained the position of consumers' sales engineer.

He left Dunfermline in 1934 to become chief technical assistant to the Harrogate Corporation. After three years he was appointed deputy electrical engineer and manager and two years later became borough electrical engineer and manager. He held this appointment until the nationalization of the industry, when in 1948 he became manager of Harrogate Sub-Area of the North Eastern Electricity Board. Later that year he was appointed to the position which he held at the time of his death, namely manager, South of Scotland Electricity Board, Glasgow Area.

He took an active part in everything connected with the industry and served on the Council of the Incorporated Municipal Electrical Association and several of its technical committees; on the Central Electricity Board's District Consultative Technical Committee; as a member of the British Electrical and Allied Industries Research Association Technical Committee, Section 'O'—Overhead lines; as a past-president and member of the National Executive Committee of the Association of Managerial and Electrical Executives, representing this latter organization on the N.J.M.C.; and as a member of Council of the Association of Public Lighting Engineers. He was a member of the Institute of Fuel and a fellow of the Illuminating Engineering Society.

In his younger days he was a keen all-round sportsman and indulged in both codes of football. Latterly he cultivated golf and was a past-captain of Pannal Golf Club, Harrogate. He was possessed of a most even-tempered manner and a keen sense of humour and was able to devote a nimble brain to any problems which were presented to him. In his relations with his staff he enjoyed harmony and always made himself available at any time to representations from his employees. He is survived by his widow and two daughters.

He joined The Institution as a Student in 1922 and was elected a

Graduate in 1926, an Associate in 1929, an Associate Member in 1930 and a Member in 1942. He served on the North Midland Centre Committee from 1937 to 1946, being vice-chairman from 1937 to 1942 and chairman in 1945–1946; on the Scottish Centre Committee from 1950 to 1952; and on the South-West Scotland Sub-Centre Committee from 1952 to 1954. E. F. S.

HERBERT ALLAN LAMB

Herbert Allan Lamb who died on the 13th October 1960 was essentially of a modest disposition, but he made an impact on all with whom he came in contact, both professionally and personally. He was born in Co. Durham on the 28th January 1907 and was educated at Bede Collegiate School, Sunderland, at Ashville College, Harrogate, and at Sunderland Technical College.

At 14 years of age he was apprenticed as an electrician to Lambton Hetton and Joicey Collieries, Co. Durham, where he remained until he joined A. Reyrolle as junior technical assistant in 1929. After six years with the company he joined Harland Engineering Co., Scotland, as switchgear test and inspection engineer. He moved after two years to broaden his experience and was appointed protection engineer to Ferguson Pailin, Manchester.

The war intervened and he joined the Royal Electrical and Mechanical Engineers in 1942, becoming a captain at the Directorate of Mechanical Engineering, War Office. In 1946 he was appointed chief switchgear engineer to the South Wales Switchgear Co., Blackwood, and was promoted deputy to the general manager in 1948. In 1951 he was appointed general manager of Aberdare Cables Ltd. and was elected in 1955 to the board of directors, where he remained until his death.

Although he had no very definite hobbies, he took a great interest in classical music. There are many engineers who will treasure his memory as a man of great sincerity and an engineer of very sound judgment. He is survived by his widow and a daughter.

He joined The Institution as a Student in 1932 and was elected a Graduate in 1933, an Associate Member in 1937 and a Member in 1951. D. E. L.

HARRY MOSS

Harry Moss who was born on the 23rd April 1879 died in hospital on the 20th November 1960 following an operation. He was educated at Derbyshire County Council schools and received practical training with four companies before becoming contract foreman for three years with John Worthington and Co., Hanley.

In 1903 he started his own business in Hanley, but after two years became manager and estimating engineer with David Wilson and Co., Huddersfield. In 1906 he transferred to the same position with Charles Pullan before going into business once more on his own account in Bradford in 1909. He retired in 1940 but continued to do work on behalf of insurance companies and acted as an expert witness in several cases concerning electrical accidents. During the Second World War he undertook the supervision of two local electrical businesses that had staff difficulties and the training of Royal Engineers at Bradford Technical College.

He gave many lectures to various bodies in the Bradford district—his favourite subject was safety of electrical installations and apparatus. He was president for two years and a member of the Council for nearly 40 years of the Bradford Engineering Society and was a past-chairman of the Bradford branch of the Electrical Contractors' Association and of the local branch of the Illuminating Engineering Society.

Until about one month before his death he was still contributing articles to the local and technical Press. He had an excellent record of public service, was widely known for his good nature and cheerfulness, and was a well known local character who was ever ready to take a stand against red tape. When in his own business, he had his stationery headed 'O.H.M.S.' (On Harry Moss's Service) and was taken to task by the Postmaster General.

He is survived by his widow and a daughter.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1948. He served on the North Midland Centre Committee from 1937 to 1940. T. H. C.

EUSTACE THOMAS

Eustace Thomas who died on the 11th October 1960 was born near Aylesbury on the 23rd February 1869. He was educated at the City of London School and at Finsbury Technical College, remaining at the college as chief assistant to Prof. Silvanus Thompson. In 1897 he became an engineer with the British Thomson-Houston Co. In 1900 he joined his two brothers, Bertram and Frank, to form Bertram Thomas (Engineers), Manchester, with whom he stayed as co-proprietor and director until he retired in 1955.

He was responsible for all the electrical engineering development of the company for 55 years, during which time it established its position as a leading maker of d.c. switchgear in this country with a world-wide reputation. He was responsible for the design of circuit-breakers and switchboards for all the Services (but particularly the Admiralty), for industry and later for traction work (tramways, trolley-buses and railways) where his personally designed high-speed circuit-breaker became well known and adopted. He travelled all over the world, often in the course of his work, often for adventure.

He was a man of intense vitality, with an interest in many things, and was equally successful in his various sporting activities. In 1921, when already over 50, he broke the Fell record in the Lake District by walking 66½ miles with 25000ft of ascent in 24 hours. Not satisfied with this he went for a further 4½ hours, reaching a total of 75 miles and 30000ft of ascent. Later he became the first Englishman to climb all the Swiss mountain peaks of 4000 metres and over and climbed over 83 summits within six years. He designed and developed a rescue stretcher used by most mountain rescue teams today.

In his earlier days he played golf until he became a scratch player. At the age of 60 he learnt to fly, holding a silver award for gliding—at 70 he flew his own aircraft, with a co-pilot, to Egypt and at 85 flew an aircraft over Australia.

He was a man of extremely simple and unaffected ways, deeply interested in everything new, friendly with all with whom he came in contact, old or young. One of his most endearing characteristics was that of being willing and able to discuss, work and enjoy leisure with people often half or even a third of his age.

He joined The Institution as a Student in 1886 and was elected an Associate in 1895 and a Member in 1913. His paper entitled 'The management of engineering workshops' was published in the *Journal* in 1908. A. M. B.

RICHARD FFOLLIOTT WILLIS

Col. Richard ffolliott Willis, C.B., R.M.L.I., who died on the 18th July 1960 was 84 years of age. Commissioned in the Royal Marine Light Infantry in 1894, he attended the Ordnance College, Woolwich, in 1900 and later that year attained the rank of captain.

From 1901 to 1905 he was seconded to the Army Ordnance Department at Barbados and on his return to England was appointed ordnance officer at Aldershot. In 1907 he served in H.M.S. *Majestic* and *Albion* and qualified in wireless telegraphy in H.M.S. *Vernon* in 1908, being appointed in that year in charge of the wireless-telegraphy station at Cleethorpes, which had the duty of passing messages to H.M. ships in vital areas in home waters.

In 1913 he was appointed to H.M.S. *Cormorant* in charge of the very important wireless-telegraphy stations at Gibraltar, holding this position until the end of the First World War. During this time the high-power station at Gibraltar maintained constant touch with the Admiralty and with Malta. Ships at sea were also served by the medium-power stations. The services thus provided were an essential factor in maintaining sea communication in large areas of the Atlantic and the Mediterranean. On many occasions he received an expression of their Lordships' appreciation in connection with his many experiments and improvements in wireless communication during this period, which saw the start of the transition from spark to continuous wave.

In 1919 he returned to England and served at the signal school at H.M.S. *Victory* and in 1921 was appointed for wireless-telegraphy duties on the staff of the Commander-in-Chief Western Approaches, attaining the rank of lieutenant-colonel in 1922. He retired from the corps in 1923 at his own request and was promoted colonel (retired). He was appointed a Companion of the Bath in 1919.

He is survived by his widow.

He joined The Institution as an Associate in 1901 and was elected an Associate Member in 1909 and a Member in 1912. J. W. S. D.

HARRY EGERTON WIMPERIS

Harry Egerton Wimperis, C.B., C.B.E., D.ENG., M.A., who died on the 16th July 1960 was born on the 27th August 1876. He was educated at the Royal College of Science (Tyndall Prizeman) and became a Whitworth Scholar and a scholar of Gonville and Caius College, Cambridge, where he took the mechanical sciences tripos.

Declining a fellowship at Cambridge and having had some previous practical experience as a fitter's apprentice with the South Western Railway, Brighton, he sought further experience as assistant to the chief electrical engineer with Armstrong-Whitworth and Co., Elswick. He was selected in 1901 as engineering adviser to the Crown Agents for the Colonies, thus starting a career in the Government service.

He early showed an inventive genius. The accelerometer which bears his name dates from 1909, and the gyro-turn indicator followed in 1910. He became an experimental officer in the Royal Naval Air Service in 1915, and there quickly followed the invention in 1917 of the course-setting bomb sight which, with modifications and improvements, remained the standard aid till just before the Second World War.

It was during this period that the Air Ministry Laboratory, with Wimperis as its chief, was started in a few rooms in the basement of Imperial College. When the Air Ministry, inspired by the Admiralty's example, decided to appoint a director of scientific research in 1925, the choice was Wimperis. He in this period really founded what is now the defence element of the Scientific Civil Service. With his wife's whole-hearted support, he took a personal interest in the scientific staff and so moulded them into an effective scientific team which finally won the respect of the Air Ministry.

His encouragement of the Cierva autogyro was an example of his wisdom and judgment in selecting a front on which to advance. He was also instrumental in the formation in 1934 of the Tizard Committee for the Scientific Survey of Air Defence, and so the Royal Air Force became possessed of radar.

He was Wilbur Wright lecturer at the Royal Aeronautical Society in 1932 and president from 1936 to 1938; an Honorary Fellow of the American Institute of Aeronautical Sciences; a member of the Executive Committee of the National Physical Laboratory from 1931 to 1937; and a member of the Aeronautical Research Committee.

After retirement from the Air Ministry in 1937, he visited Australia to advise on an aeronautical research policy. He was president of the engineering section of the British Association in 1939, Thomas Hawksley Lecturer in 1944, and an honorary fellow and Crown Governor of Imperial College.

Wimperis was a chief who set high ideals for himself and his staff and demanded the best; a lazy or slipshod approach brought a biting reproof. His courage and wisdom, added to his innate kindliness and courtesy, endeared him to those who were privileged to work with him as he laid the foundations of modern defence science. He is survived by his widow and three daughters.

He joined The Institution as an Associate Member in 1902 and was elected a Member in 1912. He served as a member of Council from 1911 to 1914. He was appointed a Commander of the Order of the British Empire in 1928 and a Companion of the Bath in 1935. F. S. B.

ROWLAND WRIGHT

Rowland Wright, M.B.E., who died on the 29th December 1960 was born on the 1st November 1901. He was educated at Rutlish School, Merton, received his technical education at Rugby Technical College part-time and at City and Guilds College, London, and served an apprenticeship with British Thomson-Houston, Rugby. In 1926 he became assistant charge engineer with Leicestershire and Warwickshire Electric Power Co., Hinckley.

In 1928 he joined the Madras Electric Supply Corporation and when the undertaking was nationalized in 1947 was chief generating engineer. The Madras Government retained his services on thermal-power-station construction work and he was seconded as resident engineer to Merz and McLellan for the building of the Basin Bridge 'B' station. In 1951 he joined Buckingham and Carnatic Co., Madras, becoming their chief engineer in 1954 and remaining in this office until he retired in 1960.

A keen all-round and gifted athlete, he played cricket and tennis regularly and football to an age when most of his contemporaries found the Madras climate too much for such active exercise. A gentle and friendly disposition endeared him to Indians and Europeans alike, and many mourn his early death. He is survived by his widow, a son and a daughter.

He joined The Institution as an Associate Member in 1931 and was elected a Member in 1947. He served on the Madras Oversea Committee from 1940 to 1959, being honorary secretary from 1947 to 1957 and chairman from 1957 to 1959. He was appointed a Member of the Order of the British Empire in 1943. F. H. S.

SOME RECENT BOOKS

ELECTRICAL NOISE

W. R. BENNETT

McGRAW-HILL. 1960. 280 PP. £3 17S. 6D.

THE subject of electrical noise has so many ramifications that no single text can deal thoroughly with all of them, and the author will naturally emphasize the topics that interest him. This book sets out to explain in simple terms for the non-specialist what is involved in minimizing and in measuring noise, and the first three chapters conform admirably to this plan. Nyquist's transmission-line proof of the formula for Johnson noise is avoided by considering the mechanism of metallic conduction (treated in outline) and the interaction between circuits and the electromagnetic field of black-body radiation.

The book has a bias towards circuit theory; but Campbell's theorems are not mentioned, and it seems unnecessarily artificial to derive the spectrum of shot noise in terms of the limiting case of a resonant load circuit with Q tending to infinity. But it is useful to have the analysis of noise in passive networks extended to include non-reciprocal networks. It would have seemed more natural, however, to deal with the Haus and Adler noise measure immediately after 'Noise figures of composite networks' instead of deferring it to the next chapter.

The treatments of electron-beam amplifiers and of v.h.f. noise sources are sketchy and sparse in quantitative data, but there is a useful treatment of 'nonlinear-reactance amplifiers' (parametric amplifiers). The discussion of sampling, and the very brief reference to information theory in the Shannon sense, do not seem naturally integrated with the rest of the material.

The inevitable misprints are not misleading, but the reader is halted on p. 246 by meeting the phrase 'ratio of frequency deviation to signal-to-frequency'.

To sum up, this is a useful work for those concerned mainly with the relation of noise to circuit configuration. D. A. BELL

VIDEO TAPE RECORDING

J. BERNSTEIN

NEW YORK: RIDER. LONDON: CHAPMAN AND HALL. 1960. 268 PP. £3 12S.

ACCORDING to its preface this text is aimed at all those working in the field of video-tape recording, including production personnel such as directors, cameramen, etc., as well as engineers. It would seem to be too technical for the average production person in the United Kingdom and is not sufficiently technical for those engineers who are engaged in the operation and maintenance of video-tape recorders.

Its greatest value will probably be to television engineers who are not engaged in video-tape-recording work but who would like an introduction to the subject. Even they will probably wish to skip several very elementary chapters on the basic principles of television, but they will find video-tape recording described in a simple and clear manner.

For engineers engaged in this work the chapters on the theory of recording are too brief, and details of equipment are in some cases already out of date. This is inevitable in any work attempting to deal in too much detail with the actual recorders used in this rapidly developing field. It means that frequent reissues will be necessary if the book is to maintain its claim of providing a comprehensive and up-to-date coverage of the techniques of video-tape recording.

A volume of this type would have a greatly enhanced value if it were to provide a list of references to the original papers on video-tape recording, and it is to be hoped that this omission will be rectified in any future edition and that at the same time the opportunity will be taken to eliminate the numerous (but, fortunately, fairly obvious) errors in the present publication. J. REDMOND

THE MAGNETODYNAMICS OF CONDUCTING FLUIDS

D. BERSHADER (*Editor*)

STANFORD: UNIVERSITY PRESS. LONDON: OXFORD UNIVERSITY PRESS. 1959. 145 PP. 36S.

FOR a number of years the Palo Alto Laboratory of the Lockheed Aircraft Corporation has sponsored a symposium on magnetohydrodynamics and subsequently published the principal papers in book form. This volume is the third of the series and contains seven papers that investigate the behaviour of conducting fluids in magnetic fields.

The papers are largely analytical: problems of wave propagation are considered by Profs. Grad and Cole, flow and stability by Profs. Resler and Carrier and Dr. Busemann. Two contributions introduce experimental studies: Dr. Mitchner examines flow problems which are amenable to study in high-velocity-shock tubes, and Dr. Petschek reports some interesting investigations of a problem of magneto-hydrodynamic lift that can be encountered in high-speed flight.

Magnetohydrodynamics is a subject of increasing interest to many of the sciences, and the two previous volumes indicated this wide range. This work, in concentrating on the fluid-mechanics aspects, will be of greatest value to the aerodynamicist. However, the papers are lucidly presented and well referenced and should be of value to other advanced workers concerned with problems of fluid flow in the presence of magnetic fields. R. CARRUTHERS

DIGITAL COUNTERS AND COMPUTERS

E. BUKSTEIN

NEW YORK: RINEHART. 1960. 248 PP. £2 16S.

THE primary concern here is with circuits of the type used in digital computers. The reader is introduced to diode and triode shaping circuits, but unfortunately the pentode squaring circuit is omitted. Other circuits described in the introduction include blocking oscillators and multivibrators.

The main theme of the first half of the volume is the binary counter or scaler, and various triode and transistor versions are explained. Methods of connecting these scalers to build binary or decimal or other counters are shown. There is a short section devoted to gas-filled decimal counting and display devices.

The second half begins with descriptions of circuits used for performing computer logic employing diodes, thermionic valves or transistors. There are brief explanations of other digital-computer equipment, together with various examples, supplied by manufacturers, of actual circuits used in their computers. This book can be recommended as a useful introduction for students. R. L. GRIMSDALE

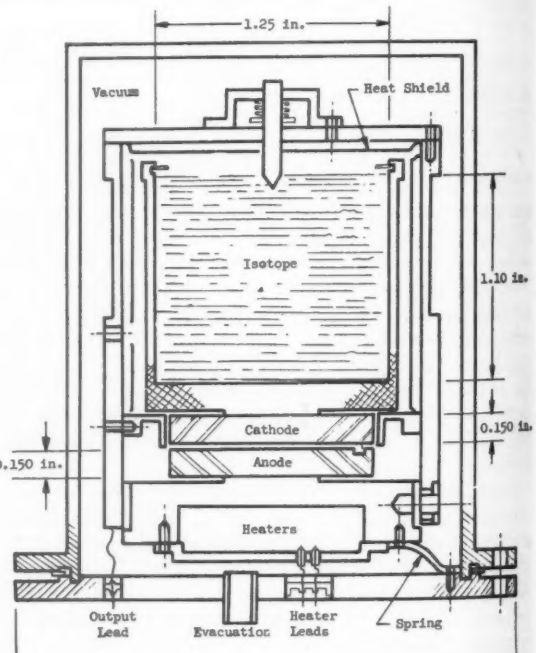
THERMOELECTRIC MATERIALS AND DEVICES

I. B. CADOFF and E. MILLER (*Editors*)

NEW YORK: REINHOLD. LONDON: CHAPMAN AND HALL. 1960. 344 PP. £3 19S.

TWENTY-FOUR authors contribute to this book, which is a compilation of lectures in a course sponsored by the Department of Metallurgical Engineering at New York University.

Thermoelectricity, a long-established science, was until quite recently of only minor engineering interest. Within the last five years, however, that interest has rapidly intensified. More is now understood of the physics and thermodynamics,



Prototype design of thermionic convertor

and the parallel development of semiconductors has added valuable new thermoelectric materials.

Despite the speed with which the work has been produced—the final lectures were given in June 1960—the text is well edited. It falls roughly into three parts: the physics of thermoelectrics, the properties of materials, and the basic design of thermoelectric generators.

A chapter on thermionic convertors is included for comparison with solid-state processes, for the former can be considered as a type of thermoelectric generator with one gaseous element. The diagram reproduced with this review shows a prototype design for a thermionic convertor intended for application in a space-vehicle. Using a 6·4cm² emitter surface on a cathode heated by means of a radioisotope to 1400°K, it produces 3·5W at 0·65V with an efficiency of 5·9%.

The volume is a well presented and up-to-date interim report, showing the results of the multi-directed attack on the theory and application of thermoelectrics. It assesses excellently the present state of the art in the United States, an art that may well have a future of real engineering importance.

M. G. SAY

UNITS, DIMENSIONS, AND DIMENSIONLESS NUMBERS

D. C. IPSEN

McGRAW-HILL. 1960. 236 PP. £2 10S. 6D.

THIS volume is largely concerned with techniques of handling units, of discovering requirements for similitude and of dimensional analysis. This approach keeps the subject securely tied to algebra, where it belongs, and preserves it from the metaphysics into which some of the more theoretical physicists have taken it. It is a useful work for engineering students and for those who have to instruct them in the practical use of theory of dimensions.

A large number of examples help to illustrate principles. The nature of units is discussed more fully and more deeply than that of dimensions. The latter are treated rather superficially, which becomes most evident in chapter 7—'Units and dimensions of electricity'. The author expresses certain sound axioms but has dodged the task of applying them consistently to the various mutually incompatible theories about dimensions, all of which have their ardent defenders.

Had he been more thorough, his axioms would have led him to a selection between the rival systems. As it is, he does not venture further than a timid deprecation of those systems that a more rigorous analysis would prove indefensible. The result is a book of practical use at an elementary level but not one that will reduce the prevalent confusion about the nature of physical concepts.

REGINALD O. KAPP

THE DIELECTRIC CIRCUIT

P. KEMP

CHAPMAN AND HALL. 1960. 219 PP. £2 5S.

THIS is a new addition to the long-established series of 'Monographs on electrical engineering'. Disregarding the arguable validity of the term 'circuit' in the title, a reader might legitimately expect a comprehensive treatment of electric-field phenomena in stress-distribution and dielectric behaviour, and a discussion of modern insulation design. He would be disappointed.

The book certainly opens with a chapter headed 'Electrostatic theory', but it is confused as well as being elementary. The properties of dielectrics go no further than a few relative permittivities and some very brief and somewhat naïve notes on breakdown. The extended treatment of capacitance in a.c. circuits and of *LCR* transients seems unnecessary; and even here the author swithers between $G + jB$ and $G - jB$ for the admittance of a capacitive circuit.

There is nothing on insulation design, no mention of polarization or displacement current, no hint of the problems of the electric field in (say) a Van de Graaff generator or a high-voltage transformer. The standard is about that of an Ordinary National Certificate during the shellac and paraffin-wax era. The words 'polythene' and 'ester', for example, never appear; and although there is one reference to 'the so-called "bundled" conductor arrangement', the author appears to think that it means an increase in the over-all diameter of the conductor.

M. G. SAY

AN INTRODUCTION TO ELECTROTECHNOLOGY

S. J. KOWALSKI

CHAPMAN AND HALL. 1960. 301 PP. 35S.

THE author claims that this new work covers the requirements of Part I: Applied Electricity, for the London B.Sc.(Eng.) degree. A good textbook for undergraduates needs a better basis for its material than is provided, as in the present instance, by the amplification of a set of lecture notes, however well these may have been prepared. Any text on this subject must present the fundamental principles and concepts in a logical and acceptable way. No author or lecturer dealing with undergraduates can be a law unto himself, ignoring the normal approach: this would lead to academic chaos.

The author has developed the topic in a manner quite unacceptable to the greater majority of lecturers. For instance, he defines resistance as power divided by the square of the current, and then derives voltage from Ohm's law! The author, probably unintentionally, perpetuates the common error of expressing the value of the newton in terms of the pound-force, a unit which varies from place to place. The subject should be developed purely on the M.K.S. system of units and the student spared the distractions and time-wasting exercises which result from the quite unnecessary introduction and use of gravitational units.

Electrical engineers now have a sound and logical system; let this be the only one: all problems should be expressed in M.K.S. units, and data given in any other units should be converted into metric quantities. Nothing contributes so much to the dismay and confusion of the average student as the multitudinous systems of units used in engineering education.

The text is attractively written and is easily read as a result of the format and good printing. The nomenclature and abbreviations are generally those recommended by the British

Standards Institution, but the author is not consistent. For instance, the origin of a vector diagram is seldom marked, nor are unit abbreviations always employed after numerical quantities. For these and many other reasons, such as the introduction of symbolic notation and the treatment of transformers, the book cannot be recommended for engineering students. P. F. SOPER

ELECTRODYNAMICS OF CONTINUOUS MEDIA

L. D. LANDAU and E. M. LIFSHITZ

PERGAMON PRESS. 1960. 417 PP. £4 4S.

HERE is mathematical physics in the grand manner: a course of nine volumes, of which this is the eighth. It is a staggering thought that the whole field of theoretical physics can thus be surveyed by any two men.

This text on electrodynamics is a masterpiece. In spite of the advanced nature of the topics discussed, the book is lucidly written. The mathematical apparatus is never obtrusive, but physical concepts are kept to the forefront. Some of these concepts will be unfamiliar to engineers. Once this is accepted, it can be turned to good advantage, because the unfamiliarity highlights the power and beauty of the ideas.

For instance, in discussing the magnetic symmetry of crystals, the authors begin with the sentence: 'There is a profound difference between the electric properties of crystals and their magnetic properties, which results from a difference in the behaviour of charges and currents with respect to a change in the sign of the time'. There is much to ponder here, as indeed on almost every page of the work.

Although the authors restrict themselves to continuous media, they continually relate the theory to the behaviour of physical materials. Examples of such discussion are: piezoelectrics, ferroelectrics and magnetic anisotropy. Another useful feature is the constant reference to thermodynamic considerations. Electrodynamics is thus firmly linked to thermodynamics. The chapter on magnetic fluid dynamics also deserves special mention.

Throughout, there are large numbers of worked examples which will repay careful study. This book should be available in any research organization worthy of its name.

P. HAMMOND

ANALOG COMPUTATION IN ENGINEERING DESIGN

A. E. ROGERS and T. W. CONNOLLY

McGRAW-HILL. 1960. 450 PP. £6 4S.

IT is both the strength and the weakness of analogue computing that dynamic problems can be solved with its aid and yet without a knowledge of analytic methods of solution that may be available; this book shows, by a survey of the relevant mathematics, how much more powerful the technique can become in the hands of a mathematically inclined engineer, and indicates clearly that analogue computing covers much more than just simulation.

Born of a series of lectures given to graduate students in the United States, its emphasis is on the mathematics of dynamic systems as a necessary background to the solution of dynamic problems with the analogue computer. For completeness it contains descriptions of analogue-computing elements, but its main value lies in its survey of the underlying mathematics.

The survey of linear analysis, the consideration of non-linearities, and the discussion on random signals are of great value, as they give a unity to the subject that is not easily attained even by intensive study of more detailed and specialized texts. There are sections on partial differential equations, on algebraic equations and on related problems and a valuable chapter on the adjoint computing technique, which is of particular interest. These mathematical matters occupy about 200 pages.

There is a series of chapters dealing with typical problems from most branches of engineering, including process control and nuclear reactors, covering about 100 pages. A well tried procedure of problem preparation and documentation is described in detail, and there are useful notes on laboratory organization and staffing. The references are numerous, and there is an excellent bibliography.

This is a thought-provoking work and should be in every analogue-computing laboratory. It is worthy of attention by all engineers who have to consider design or analysis of dynamic systems, both for the way the mathematics is surveyed and for the way in which the role of the analogue computer is delineated. R. A. LAWS

ANALOG AND DIGITAL COMPUTER TECHNOLOGY

N. R. SCOTT

McGRAW-HILL. 1960. 522 PP. £4 19S.

THE author states in the preface that the scope of this work might be more precisely indicated by the title 'An introduction to the application and the engineering design of direct-coupled electronic differential analysers and of electronic digital computers'. The first four chapters deal with electronic differential analysers and the last seven with digital computers.

He goes on to say 'In each of these two major parts of the book, the computer is first treated as a tool, and methods of using it to solve problems are introduced; then, its design is approached from an engineering point of view, and the appropriate engineering technology is introduced. The book is intended primarily for use by electrical engineers and this double approach to each class of computer arises from the fact that the electrical engineer's relation to computers is unique, since he alone both uses and designs computers'.

The text is based on graduate lectures given at the University of Michigan. One has only to dip into it to appreciate its comprehensiveness and its quality, and I would wholeheartedly recommend it to engineers who wish to make a serious study of the topics with which it deals. M. V. WILKES

CLASSICAL ELECTRICITY AND MAGNETISM

E. S. SHIRE

CAMBRIDGE UNIVERSITY PRESS. 1960. 396 PP. £2 5S.

THIS text, primarily intended for physics students, is intermediate between an elementary first account and advanced

mathematical treatments. It should prove of value to the serious student of electrical engineering in his junior years at the university; one aspect of particular interest is the emphasis on the historical development of electrical science and the detailed accounts and discussions of the experiments of the pioneers.

The mathematics is fairly simple and, where necessary, is amplified in appendixes. Theory is given in a form adaptable to any of the well known unit systems, although it is evident that the author is more at home in C.G.S. than in M.K.S. As he says, a physicist should be able to move with ease from one system to another; but this is a degree of adaptability more often forced on the student of electrical engineering than on the student of physics by the transition from school to university.

Electrostatics and magnetostatics are well treated, the latter being conventionally based on magnetic dipoles. The author uses $\mu_0 M$ as the analogue of P, so that $B = \mu_0(H + M)$, whereas $D = \epsilon_0 E + P$. This, he explains, is an arbitrary decision, and the blame lies not with him but with the International Union of Pure and Applied Physics. The account of energy and forces, a complicated matter when magnetic material is present, is excellent, and the essential relations in the performance of a permanent magnet are not ignored.

Electromagnetic induction is adequately treated, following chapters on the magnetic field of currents and conduction, with a discussion of p.d. and e.m.f. The author, however, adopts a general definition of e.m.f. based on energy conversion which requires a resistor to have a 'back e.m.f.'. He therefore, on p. 201, gives Kirchhoff's second law in the form $\Sigma e = 0$, but four pages later changes to $\Sigma e = \Sigma RI$. In the chapter on circuit theory, the basic theorems and methods of dealing with networks are clearly explained, with a page and a half devoted to the transformer, but the engineering student will find the treatment of steady sinusoidal alternating currents a little odd. No reason is given for the use of r.m.s. values, except that 'currents and potential differences are usually expressed in r.m.s. amps and r.m.s. volts'.

When vector reactances are introduced, they are used for the purpose of finding expressions for *instantaneous* values denoted by unadorned capitals I, V, etc. So when we come on p. 233 to the average power in an a.c. circuit, we find that $P = e_{r.m.s.} I_{r.m.s.} \cos \delta$, where δ, we are told, is the *loss* angle. There follows a good introductory theoretical treatment of electromagnetic waves, with a brief description of Hertz's experiments, and an account of basic electrical measurements including absolute methods.

Finally, there is a section on 'Applied electricity'. 'Dynamos' and motors are disposed of in nine pages in the barest outline, and we are somewhat startled to find that the efficiency of a dynamo is equal to the ratio of the terminal p.d. to the generated e.m.f. Two and a half pages suffice for a.c. machines, where 3-phase systems and rotating fields are just mentioned. The author is on happier ground when he deals with electronics, and this section, including such things as mass spectrometers and particle accelerators as well as the more important applications of valves and transistors, is of interest. One wonders, however, why this chapter has been included in a work with this title.

Each section ends with a good set of examples, with answers, largely culled from the Natural Sciences Preliminary Examination and Tripos. An electrical engineering student would benefit greatly by working through them, and perhaps the author and physicists in general might benefit from a less unilateral communication system between themselves and electrical engineers.

E. G. CULLWICK

INDUCTION-TYPE INTEGRATING METERS

G. F. SHOTTER and G. F. TAGG

PITMAN. 1960. 214 PP. £3 3S.

THIS is basically about the cause of wear between the pivots and jewels in the lower bearings of induction-type integrating electricity meters, and damage to them by impact, with a section on the theory of such meters. It summarizes a large number of experiments ingeniously devised to investigate the above, and gives mathematical support to the conclusions.

It is perhaps inevitable that experiments extending over many years should relate to meters which are not of modern design, and it would be of interest to know the results of the performance of modern designs.

The work appears at a time when complete suspension of the disc and spindle is imminent, which might be expected to eliminate the trouble in the lower bearing referred to. The significance of friction in terms of revenue lost due to low-load error, in applying weighted error figures, would help to keep the matter in true perspective and would perhaps be a useful addition to the chapter on suggested figure of merit.

The book will be of special interest to students and to those engaged on meter design, as well as to supply-meter engineers in assessing life-accuracy performance from laboratory and after-service tests. The title might be made more attractive by adding the word 'electricity'.

E. ROSCOE

FUNDAMENTALS OF SIGNAL THEORY

J. L. STEWART

McGRAW-HILL. 1960. 346 PP. £3 10S.

THIS is a good book, covering a slightly unusual range of topics. The introductory parts present no mathematical difficulty and so should gain the confidence of the student, who is introduced to the manipulation of determinants and matrices in chapter 2.

During a discussion of normal modes and of basic limitations of physical systems, there are two sections on poles and zeros; and then an introduction to the problem of approximation, i.e. the problem of placing the poles and zeros of a system which is being designed in such a way that the response of the system will approximate to that desired.

The next portion, nearly a third of the volume, is concerned with operational technique and has successive chapters on 'Operational methods', 'The direct Laplace transformation', 'Contour integration' and 'Further aspects of complex variable theory'. This last chapter describes Laplace inversion, Hilbert transforms and Bode's attenuation-integral and phase-integral theorems. Chapter 10 and the greater part of chapter 11 switch from circuits to signals in order to discuss both discrete and continuous spectra.

There are a number of references for more advanced treatment to well-known works by authors such as Bode, Guillemin and Tuttle and the M.I.T. Radiation Laboratory Series. But the reference on p. 315 to Cramér's 'Mathematical methods of statistics' for general information on statistics is hard on the reader who has negligible knowledge of statistics and whose mathematical equipment is only that required for the present text.

The treatment of stochastic processes is cursory, which could be forgiven in a book which deals so well with circuit properties and systematic signals, were it not that chapter 11 includes a discussion of the Wiener filter. D. A. BELL

ANALYTICAL TECHNIQUES FOR NON-LINEAR CONTROL SYSTEMS

J. C. WEST

ENGLISH UNIVERSITIES PRESS. 1960. 221 PP. 25S.

CLOSED-LOOP control systems are invariably non-linear, either fundamentally or by design. The existence of these non-linear systems creates a dual challenge: analytical techniques are needed to assist in the understanding of their behaviour, and synthesis techniques to enable optimum systems to be designed and to indicate new ways of deliberately using non-linear elements to achieve prescribed control requirements.

Classical non-linear mechanics is too narrow to satisfy this demand; its methods are for the most part restricted to the exact solution of first- or second-order differential equations, having comparatively mild deviations from linearity. The techniques which Prof. West and other workers have devised, and which are the subject of this book, provide a sound engineering basis for analysis and synthesis of control systems containing one or more amplitude-dependent non-linearities.

A knowledge of linear-control-system theory is presupposed, though one chapter is devoted to an excellent précis of this. In the rest of the volume, three major techniques are discussed. They are, respectively, phase-plane methods, describing-function methods, and the equivalent-gain technique for systems with random inputs and disturbances. In each of these fields, much of the work described is the result of researches by the author and his colleagues.

The text includes descriptions of recent advances in the use of phase-plane methods for stability predictions and of the dual-describing-function and incremental-Nyquist-diagram techniques for predicting sub-harmonic resonance, jump phenomena and other essentially non-linear behaviour. The mathematical discussion is presented without unnecessary rigour and is supported by many practical examples.

There are several typographical errors, mainly in mathematical expressions. The figures, though always clear in lay-out, sometimes invite the touch of a professional draughtsman. These are the only blemishes on a work whose quality of exposition is high. It is a rare pleasure nowadays to see a British book on automatic control, and this particular one should compete both in price and in content with the trans-atlantic publications on similar themes. It can be recommended without reserve both to postgraduate students and to control engineers. P. H. HAMMOND

ANALYSIS AND DESIGN OF FEEDBACK CONTROL SYSTEMS

G. J. THALER and R. G. BROWN

McGRAW-HILL. 2ND EDITION. 1960. 648 PP. £5 12S. 6D.

THIS is the second edition of a well-known work which appeared in 1953 under the title 'Servomechanisms analysis'. There have been major changes in this field over the last few years, the first of which—the acceptance by engineers, as distinct from mathematicians, of the theories of the statistical behaviour of systems subjected to randomly varying signals and disturbances—has stimulated work on optimization, the second major advance. The third area of progress, and probably the one of greatest impact on design, is the breakthrough of engineers' approximate techniques in handling non-linear aspects of control, a subject previously formidable and often intractable.

The whole emphasis of this new edition is on optimum design; two excellent chapters now appear, based on industrial practice within the authors' own considerable experience on systems now in use. Throughout the book, the design aspect is given priority and even flavours the set problems appearing at the end of each of its 14 chapters.

Non-linear considerations are discussed in full force in three long sections dealing consecutively with phase-plane analysis, describing functions, and relay systems. These, together with the treatment of sampled-data systems, form about one-quarter of the large text.

The complete absence of statistical developments is disappointing. Space considerations may have been the limiting factor, but surely the inevitable section on the Laplace transformation could have been sacrificed, and the third chapter, dealing with Newtonian mechanics and elaborating in an elementary manner on electromechanical analogies, is out of place in a text of this kind.

Like its predecessor, it is well written and excellently produced, with copious diagrams. To use the modern idiom, it is likely to rise into the top-ten bracket of those recommended. Since there are well over 100 English works on this subject, this is praise indeed. J. C. WEST

PRINCIPLES OF FEEDBACK CONTROL

C. H. WILTS

READING, MASS.: ADDISON-WESLEY. 1960. 271 PP. £3 6S.

THE disposition of American teachers of the theory of control systems to turn their teaching notes into published textbooks seems irrepressible. Dr. Charles H. Wilts is a Professor of Electrical Engineering at the California Institute of Technology, and his book is not unworthy of this distinguished centre for engineering education.

Dr. Wilts's text has certain merits. It is short. It has the feature, helpful to students, that the several methods of analysing the behaviour of linear systems are treated in close conjunction, and examples are worked out successively, using the Nyquist locus, the log-gain log-frequency graph and the root locus. Exercises and examples are given after each chapter.

The topics discussed are mainly limited to the formal theory of linear systems with feedback, but there are sections on the describing function and on sampling systems. The limitation is that the treatment is formal and mathematical, never explanatory or physical. It is a work about equations, not about devices. The mathematics is usually merely stated; the student is presumed to know it in advance. There is no attempt to exploit the virtue of the subject of control systems as a medium for illustrating and illuminating the mathematics.

As a short, formal, and rather mathematical approach, the volume has the merits of being clear and well produced, but as such it will help only a limited class of reader. Allusions to other work are confined to three or four references at the end of certain chapters only, and are scarcely adequate.

A. TUSTIN

AIRCRAFT ELECTRICAL ENGINEERING

H. ZEFFERT

NEWNES. 1960. 726 PP. £4 10S.

IN the foreword, Sir George Edwards, who has more aeroplane exports to his credit than anyone else this side of the Atlantic, makes the sobering point that a £2 million aeroplane might be lost by the faulty design or maintenance of an electrical component costing a few pounds.

The author states his problem as being to condense the vast amount of information available. The information is condensed more than the words in which it is presented, and the expert requiring a concise book of reference is apt to be lost in a flood and have to wade in to find the answers he seeks. The man who is laying out a new aircraft installation will derive much sound guidance on what has been tried, discarded, and should not be tried again. The designer of equipment will look in vain for any substitute for his own often bitter experience.

Among components, 'Motors' are given three pages, 'Actuators' 14 pages, mainly general, 'Relays, contactors and switches' 33, and 'Terminations, plugs and socket connections' 50. On the engineering of electrical systems, 'System selection' has 26 pages, 'D.C. generator systems' 34, 'A.C. systems' 80, 'Secondary systems and batteries' 40, and 'Distribution' and 'Introduction to circuit design and protection' 98.

Chapters are included on 'Control of flying surfaces' 18 pages, 'De-icing' 19, 'Engine equipment systems' 55, 'Instrument systems' 28, and 'Testing' 30 pages with suggested lay-outs for systems and components test houses. 'Lighting', 'Galley equipment' and 'Air-conditioning' together cover 43 pages, and 'Avionics' another 51. A section on 'Organisation', 16 pages long, emphasizes the heavy responsibility resting on the electrical and electronic engineers concerned with the development of a safe and successful aeroplane, but it is doubtful if this can achieve anything beyond satisfying their egos.

The text is plentifully provided with diagrams, particularly of circuitry and schematics. Undoubtedly much labour has been put into this work, and such a volume must have been expensive to produce. It is therefore a pity that it has evidently escaped the careful editing and fairly drastic pruning which would have increased its value to advanced students and professional readers.

C. G. A. WOODFORD

METHODS OF FEASIBLE DIRECTIONS

G. ZOUTENDIJK

ELSEVIER. 1960. 126 PP. 30S.

ONE of the more important applications of the electronic computer is in the field of operational research, which is concerned with optimizing a situation dependent on several variables subject to various constraints. This monograph expounds a number of methods for linear and non-linear programming, starting with a refinement of the well-known simplex method which is claimed to save many operations although it may need more storage than is available on small computers. The principal topic is the novel method from which the book takes its title. This is, in fact, a family of methods, including some previously known ones as special cases. It is applicable to linear, quadratic, and general convex problems.

The abstractness of the treatment makes this a work for established specialists rather than beginners. Even the well informed reader may regret the absence of examples and the frequent use of symbols where plain language would serve; these perhaps derive from the book's origin as a Ph.D. thesis. The usefulness of the new method cannot, of course, be properly assessed until it has been more widely studied and applied.

R. GRIMMOND

K. W. CATTERMOLE

ANNUAL DINNER OF THE ADMIRALTY ELECTRICAL ENGINEERING OFFICERS

THE Admiralty Electrical Engineering Officers held their Annual Dinner at Bath on the 7th March 1961. The dinner was the first to be held under the chairmanship of Mr. J. C. Thompson, who succeeded The Institution's President, Sir Hamish D. MacLaren, as Director of Electrical Engineering at the Admiralty. Sir Hamish was present as an official guest.

The toast 'Admiralty Electrical Engineering Officers' was proposed by Mr. E. G. Yarrow; Mr. Thompson replied. Mr. I. E. King, Director of Dockyards, Admiralty, Bath, responded to the toast of the guests proposed by Mr. H. A. L. Dawson, Assistant Director of Electrical Engineering, Admiralty, Bath.

The other guests included Sir John G. Lang, Secretary of the Admiralty; Sir Alfred J. Sims, Director-General Ships; Vice-Admiral R. T. Sandars, Director-General Dockyards and Maintenance; Rear-Admiral R. E. Washbourn, Director-General Weapons; Rear-Admiral K. R. Buckley, Chief Naval Electrical Officer; Mr. Stanley Mayne, General Secretary, Institution of Professional Civil Servants; Mr. J. H. B. Chapman, Director of Naval Construction; Rear-Admiral R. S. Hawkins, Director of Marine Engineering; Mr. H. T. Johnson, Director of Ship Production; Capt. G. E. Hunt, Director of Naval Equipment; Capt. W. S. Dawson, United States Assistant Naval Attaché; Mr. S. Bolshaw, Chief Scientific Adviser to Director-General Ships; and Mr. J. E. Makin, Senior Assistant Secretary, Bath.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated in a footnote

BRITISH BROADCASTING CORPORATION

Engineering Monograph no. 31 **The power gain of multi-tiered v.h.f. transmitting aerials** by P. Knight and G. D. Monteath. London, 1960. 5s.

THIS monograph describes a method of calculating the power gain of multi-tiered v.h.f. transmitting aerials. Results, computed for a comprehensive range of variables, are presented in the form of tables.

Engineering Monograph no. 32 **A new survey of the B.B.C. experimental colour transmissions** by I. R. Atkins, A. R. Stanley and S. N. Watson. London, 1960. 5s.

THE experimental colour-television transmissions which took place from Alexandra Palace between October 1957 and April 1958 are described, together with the results of experimental work to determine the suitability of the existing distribution network. An account is given of experience gained in outside broadcasts.

Engineering Monograph no. 33 **Sensitometric control in film making** by L. J. Wheeler. London, 1960. 5s.

SENSITOMETRIC control of telerecordings made at Alexandra Palace is discussed, among other things, in this monograph.

Engineering Monograph no. 34 **A mobile laboratory for u.h.f. and v.h.f. television surveys** by E. W. Taylor and L. C. Munn. London, 1961. 5s.

A MOBILE laboratory, equipped for the measurement of vision field strength and test waveforms and for the subjective assessment of the picture quality resulting from transmissions from Crystal Palace, was used by the B.B.C. Research Department during Band I/Band V comparison tests carried out in 1957–58. The laboratory is described in this report.

B.B.C. handbook 1961. London, 1960. 6s.

THE engineering section records the progress made in sound and television broadcasting. By 1960 there were 20 v.h.f. sound-transmitting stations, covering over 97% of the population. About 50% of the sound programmes are recorded. Stereophonic broadcasting experiments have been carried out. The B.B.C. television service is now within reach of approximately 98·8% of the population. Colour-television transmissions have been made experimentally.

BRITISH STANDARDS INSTITUTION

B.S. 2818: Part 2: 1961. **Auxiliaries for operation of fluorescent lamps.** Part 2—Capacitors. 6s.

CONTINUOUSLY rated a.c. capacitors, up to and including 20 μF capacitance, operating in circuit with all types of tubular fluorescent lamp complying with B.S. 1853 'Tubular fluorescent lamps for general lighting service', are covered by this revised edition. Capacitors manufactured to this revised specification must be marked with the year, as well as the number, of this standard because a higher level of quality has been set.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

A survey of nickel and chromium recovery in the electroplating industry by E. P. Harris. London, 1960. gratis

THE ion-exchange process for the purification and re-use of effluent solutions has great potential value compared with conventional chemical methods. At present, the handicaps with the ion-exchange process are the initial cost of the equipment and the lack of operating experience.

HEYWOOD AND CO. LTD.

Special ceramics edited by P. Popper. Heywood, London, 1960. £3

THE papers contained in this book, which were presented at a symposium held by the British Ceramic Research Association in 1959, include 'The effects of reactor irradiation on ceramic materials', 'Sintered cadmium sulphide, a photoconductive ceramic', 'Design and performance of an electric furnace for precise control of temperature in the range 700°–1300°C', 'A new high temperature heating element' and 'Carbon tube furnaces'.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 50 (50). **International electrotechnical vocabulary.** Group 50—Electrochemistry and electrometallurgy. 2nd edition. Geneva, 1960 (French/English) 27s.*

PROVISION of definitions that are sufficiently clear for each term to be understood with the same meaning by all electrical engineers is the main object of the vocabulary. Group 50 contains 391 definitions of electrochemical and electrometallurgical terms grouped into 13 sections under the headings 'General terms', 'Electric batteries (general)', 'Primary batteries', 'Storage batteries', 'Electrodeposition (general)', 'Electroplating', 'Electro-forming', 'Electro-refining', 'Electro-winning', 'Electrolytic alkali and chlorine', 'Electrochemical valves (general)', 'Electrolytic capacitors', and 'Electrolysis of fused electrolytes'.

Publication 117—2 **Recommended graphical symbols.** Part 2—Machines, transformers, primary cells and accumulators. Geneva, 1960 (French/English) 13s. 6d.*

THE four chapters into which this part is divided contain 78 symbols.

MINISTRY OF EDUCATION

Technical education in Wales. Report of the Central Advisory Council for Education (Wales). H.M.S.O., London, 1961 (English/Welsh) 7s.

PROVISION of technical education in Wales is now more than adequate, although support from industry for sandwich and other advanced courses has been disappointing. The Council recommend that the Preliminary National Certificate and the present first-year stage (S.1) of the National Certificate course should be abolished, and that entry to the course should be at what is the present second-year stage (S.2). The normal entry qualification should be a pass in four appropriate subjects at the General Certificate of Education Ordinary level, these having been gained at not more than two attempts.

The Council consider that, in the past, enrolments in mechanical and electrical engineering at the Welsh College of Advanced Technology have been too low; they hope that, other than a university degree, the Higher National Diploma and not the Higher National Certificate will become the recognized path to technological status.

MORGAN BROTHERS (PUBLISHERS) LTD.

Kempe's engineers year-book for 1961 edited by C. E. Prockter. 66th edition. 2 vols. £4 7s. 6d.

REVISED information is contained in almost every section. Additions include details of electrolytic grinding and electrodeposition of metal in the section 'Machine tools' and of arc–air cutting in 'Welding and cutting'.

* Obtainable from the Sales Department, British Standards Institution, 2 Park Street, London W.1

Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ALT, F. L. (*Editor*) 518.5

Advances in computers—Vol. 1*

New York and London: Academic Press, 1960. pp. x, 316. 24 × 15·5cm. £4

This is the first volume of a new series intended to bridge the gap between articles in periodicals and textbooks. It contains contributions by six well-known authors. General-purpose programming for business applications includes a description of schemes for dealing with files on magnetic tape. Numerical weather prediction is a mathematical account. The present state of automatic translation, programming computers to play games, machine recognition of the spoken word, and, lastly, arithmetic are the other contributions. This work was reviewed in the November 1960 *Journal*, p. 664.

ASHBY, SIR ERIC 37

Technology and the academics: an essay on universities and the scientific revolution*

London: Macmillan, 1959. pp. vii, 118. 20 × 14cm. 15s.

An interesting account of the slowness of British universities to react to the industrial revolution and the subsequent adoption, first at London, of scientific and technological training and its development up to the present. It was reviewed in the April 1959 *Journal*, p. 249.

CAMERON, J. G. P. 93 : 06

A short history of the Royal Indian Engineering College (Coopers Hill)

London: Coopers Hill Society, 1960. pp. 38. 22 × 15cm. n.p.

An interesting account of the formation of the college, the Coopers Hill site before, during and after the life of the college, the Coopers Hill Society and the Coopers Hill War Memorial Fund with its annual award in which The Institution participates.

CHERNOV, L. A. 530.145

Wave propagation in a random medium*

New York and London: McGraw-Hill, 1960. pp. viii, 168. 25·5 × 19cm. £2 18s.

This is a translation of an advanced theoretical and mathematical treatise. The first part is a study of the basic problem using the ray approximation; the second is a discussion of the diffraction theory; and the final part is an examination of how fluctuations in the incident wave affect the image formed by a focusing system. It was reviewed in the November 1960 *Journal*, p. 665.

CLEMENT, P. R., and JOHNSON, W. C. 621.31

Electrical engineering science*

New York and London: McGraw-Hill, 1960. pp. xiii, 588. 23 × 15·5cm. £3 14s.

Introductory chapters on the basic concepts of electricity and magnetism lead to a concise treatment of electromagnetic theory and Maxwell's equations in their integral form. The principles of energy conversion, with emphasis on electromechanical transducers, and the theory of lumped circuits, especially the relation between physical concepts and their mathematical formulation, are next dealt with. This is followed by chapters on measurement, transients, non-linear systems, transferences and polyphase networks. This book was reviewed in the November 1960 *Journal*, p. 665.

FANO, R. M., and others 538.3

Electromagnetic fields, energy, and forces

New York and London: John Wiley, 1960. pp. xv, 520. 23·5 × 15·5cm. £4 16s.

This is an advanced work dealing with principles rather than applications, and a familiarity with mathematics to a fairly advanced level is necessary to follow the arguments put forward. It was reviewed in the August 1960 *Journal*, p. 502.

GLEDHILL, C. S. 621.392

V.H.F. line techniques*

London: Edward Arnold, 1960. pp. iii, 60. 22 × 14cm. 12s. 6d.

Deals with the use of the circle diagram for both broad- and narrow-band matching problems. Worked examples are included. This work was reviewed in the November 1960 *Journal*, p. 666.

LIVSHITS, A. L. 621.9

Electro-erosion machining of metals*

London: Butterworths, 1960. pp. xi, 115. 22 × 14cm. 30s.

A general description of electro-erosion techniques is followed by a discussion of methods of generating current pulses and of automatic control of the machining process and information on the rate of removal of metal. Electro-spark, electro-pulse and other machine tools are described. This book was reviewed in the March 1961 *Journal*, p. 185.

P.E.P. (POLITICAL AND ECONOMIC PLANNING) 35

Advisory committees in British Government*

London: P.E.P., 1960. pp. xii, 228. 22 × 14cm. 25s.

This is a report based on a two-year study of the many standing advisory committees attached to departments of the Civil Service. It does not deal with Royal Commissions, committees of inquiry, temporary bodies or local and regional committees. It discusses the various types of committee, their composition, methods of working, function and influence.

PANOV, D. Yu. 413 : 681

Automatic translation*

London: Pergamon Press, 1960. pp. 73. 22 × 14·5cm. 21s.

Describes the BESM computer used for translating English into Russian and gives examples of translations made with it. Problems associated with translating Chinese and other languages are discussed. This book was reviewed in the August 1960 *Journal*, p. 504.

SCHURE, A. (*Editor*) 621.395.645

Low-frequency amplifiers. Low-frequency amplifier systems. 2 parts

New York: Rider. London: Chapman and Hall, 1959. Part 1. pp. vi, 79. Part 2. pp. vi, 70. 22 × 14cm. 32s. together

The first of these two elementary treatments deals with the principles of valve and transistor amplifiers, the second with design considerations.

SPIESER, R. 621.313.004.6

Krankheiten Elektrischer Maschinen, Transformatoren und Apparate; Ursachen und Folgen, Behebung und Verhütung. **2nd edition** (Faults in electrical machines, transformers and apparatus; causes and effects, elimination and prevention)

Berlin: Springer-Verlag, 1960. pp. xv, 376. 23·5 × 16cm. £4 15s.

OTHER PUBLICATIONS

AMERICAN CHEMICAL SOCIETY

Fuel cells edited by G. J. Young. A symposium held by the Gas and Fuel Division of the American Chemical Society at the 136th National Meeting in Atlantic City, September 1959*

New York: Reinhold. London: Chapman and Hall, 1960. pp. v, 154. 23·5 × 15·5cm. £2 6s.

Reviewed in the February 1961 *Journal*, p. 119.

Library accessions (continued)

BRITISH BROADCASTING CORPORATION

Sensitometric control in film making by L. J. Wheeler. Engineering Monograph 33

London: B.B.C., 1960. pp. 24. 27·5 × 22cm. 5s.

CZECHOSLOVAK ACADEMY OF SCIENCES

Transactions of the 2nd Prague conference on information theory, statistical decision functions, random processes, held at Liblice near Prague, 1st–6th June 1959, edited by J. Kožešník

Prague: Czechoslovak Academy of Sciences, 1960. pp. 842. 24 × 17·5cm. £2 15s.

DIAMOND ORDNANCE FUZE LABORATORIES

Proceedings of the symposium on microminiaturization of electronic assemblies held at the Diamond Ordnance Fuze Laboratories, 30th September–1st October 1958, edited by E. F. Horsey and L. D. Shergalis*

New York: Hayden Book Co., 1958. pp. viii, 278. 23 × 15·5cm. £4 8s.

MINISTRY OF EDUCATION

Better opportunities in technical education. Cmnd. 1254

London: H.M. Stationery Office, 1961. pp. 24. 24 × 15cm. 1s. 3d.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a summary appeared in the *Journal* under 'The Journal digest: papers to be read', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

April 1961

I **17** *Monday* The President, SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC., will open a discussion on 'The education of engineers—all's well?'§

S **19** *Wednesday* A. N. ARMAN, PH.D., F. J. MIRANDA, DR.-ING., *and* G. R. BISHOP 'Progress in oil-filled cables and their accessories' (paper 3513s) *summary:* March 1961; P. GAZZANA-PRIAROGGIA, DR.-ING., G. L. PALANDRI, DR.-ING., *and* U. A. PELAGATTI, DR.CHEM. 'The influence of ageing on the characteristics of oil-filled cable dielectric' (paper 3348s) *summary:* November 1960

U **20** *Thursday* P. J. H. RATA 'Aluminium in electrical engineering'‡; A. D. SWANSTON, B.SC., *and* B. W. TOWELL 'Diesel railway locomotives'‡; T. E. S. RICKARD, B.SC. 'Automatic programming for hot reversing mills'‡ (Joint Meeting with the London Graduate and Student Section at 6 p.m., tea at 5.30 p.m.)

M **25** *Tuesday* PROF. D. M. MACKAY, B.SC., PH.D. Lecture on 'Simulation of intelligence'†

E **26** *Wednesday* R. H. FRANKLIN, B.SC.(ENG.), *and* J. RHODES, M.B.E., B.SC.(ENG.). Lecture on 'Data transmission'†

O **27** *Thursday* PROF. R. F. WOOLMER, F.F.A.R.C.S., V.R.D. 52nd Kelvin Lecture. 'Medical electronics'‡

S **29** *Saturday* Section visit to Harwell

May 1961

E **1** *Monday* R. GRAHAM, M.ENG., J. W. H. JUSTICE *and* J. K. OXENHAM, M.A. 'Progress report on the development of a photoelectric beam-index colour-television tube and system' (paper 3468E) *summary:* February 1961

ME **2** *Tuesday* D. W. PASHLEY, PH.D. Lecture on 'Structural properties and applications of evaporated metal films'†; J. R. BALMER, B.SC. Lecture on 'Deposition of evaporated non-magnetic films'† (Joint Meeting)

3–4 *Wednesday–Thursday* Railway Modernization Conference (Joint Conference with The Institutions of Civil and Mechanical Engineers at The Institution of Civil Engineers, Great George Street, Westminster, London S.W.1; see p. 129, February 1961 *Journal*)

E **4–7** *Thursday–Sunday* Section visit to Cologne

MED **5** *Friday* DR. A. B. KINNEAR WILSON, M.B., M.R.C.P., D.P.M., will open a discussion on 'Artificial muscles'* (at 6 p.m., tea at 5.30 p.m.)

M **6** *Saturday* Section visit to Leatherhead

E **8** *Monday* E. COHEN *and* R. O. JENKINS, A.R.C.S., D.I.C., PH.D. 'The corona discharge and its application to voltage stabilization' (paper 3174E) *summary:* see p. 238; F. A. BENSON, D.ENG., PH.D., *and* P. M. CHALMERS, B.ENG. 'Impedance/frequency characteristics of glow-discharge reference tubes' (paper 3175E) *summary:* see p. 238; F. A. BENSON, D.ENG., PH.D., *and* G. P. BURDETT, B.ENG. 'Comparison of argon, krypton and xenon as admixtures in neon glow-discharge reference tubes' (paper 3420E) *summary:* January 1961

S **10** *Wednesday* M. DATTA, M.SC.TECH., PH.D. Annual Lecture. 'Electricity supply in India and its future'‡

ED **12** *Friday* B. F. GRAY, B.SC.(ENG.), *and* W. B. K. ELLIS, B.SC., will open a discussion on 'The place of transistors in National Certificate Courses'* (at 6 p.m., tea at 5.30 p.m.)

U **12–13** *Friday–Saturday* Section visit to Llandudno

E **15** *Monday* K. G. FREEMAN, B.SC. 'Circuits for the banana-tube colour-television display system' (paper 3561E) *summary:* see p. 237; H. HOWDEN 'Mechanical and manufacturing aspects of the banana-tube colour-television display system' (paper 3562E) *summary:* see p. 237; K. G. FREEMAN, B.SC., *and* B. B. OVERTON, B.SC. 'Appraisal of the banana-tube colour-television display system' (paper 3563E) *summary:* see p. 237; P. SCHAGEN, PH.D. 'The banana-tube display system—a new approach to the display of colour-television pictures' (paper 3564E) *summary:* see p. 238; R. N. JACKSON 'Colorimetry of the banana-tube colour-television display system' (paper 3565E) *summary:* see p. 238; B. A. EASTWELL, B.SC., *and* P. SCHAGEN, PH.D. 'Development of the banana tube' (paper 3566E) *summary:* see p. 238

E **17** *Wednesday* E. EASTWOOD, PH.D., M.SC., *and* B. J. O'KANE, PH.D., B.ENG. Lecture on 'Air-traffic control'†

18 *Thursday* ANNUAL GENERAL MEETING *followed, at approximately* 6.30 *p.m., by* J. A. RATCLIFFE, C.B.E., M.A., F.R.S. Lecture on 'Experimental investigation of space'‡

U **25** *Thursday* J. A. BROUGHALL, B.SC.(ENG.). Annual Lecture. 'Electric traction'‡

29–2 June *Monday–Friday* Summer Meeting in London

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available
§ An abstract will be available in advance, but no Press report will be permitted

District Meeting

ARRANGEMENTS for a District Meeting in April 1961 other than in the area of a local Centre

April 1961

HATFIELD (at Hatfield Technical College at 7 p.m., tea at 6 p.m.)

26 *Wednesday* D. H. MCCRACKEN 'Railway electrification in Great Britain'

The following elections and transfers approved by the Council of The Institution are effective from the 1st March 1961

ELECTIONS

Associate Members

ABDINASSIR, Abdalla, D.SC.
BATTERSBY, George Arthur
BURDEN, Peter Frank, B.SC.
CORKHILL, Alan Philmar, B.SC.(ENG.)
CORNEY, Charles Terence, B.SC.
FISHER, Frank James
MOORE, John Stanley
SEN, Gourish Chandra, M.SC., B.SC.TECH.
SIUKOLA, Matti Solmu Olavi, PH.D.
SMITH, Derek Leslie Anthony, B.SC.(ENG.)
SMITH, George William
SPURLOCK, Kenneth Ernest, M.B.E., B.SC.
STEPHENSON, William Lawrence, B.SC.
SUMMERVILLE, Bernard
TIDEY, Laurence Charles
TOMBS, Albert Henry
YODAIKEN, Julius, B.SC.(ENG.)

Companion

FRANCIS-CARTER, Charles Francis Jack

Associates

FERMIN, Frederick Leonard Cleveland
HOLLINGUM, Lewis George Horatio
SANDERSON, Kenneth
SKACEL, George
SKEY, Paul Lonsdale
VISWANATH, Col. Gobichettipalayam Srikantan, B.E.

TRANSFERS

Associate Member to Member

BAKER, Charles Henry
BALCHIN, Douglas Bernard, B.SC.(ENG.)
BROADWAY, Leonard Francis, B.SC., PH.D.
BROCKBANK, Robert Alston, PH.D., B.SC.
CHOPRA, Mohan Lal, B.A.
CLARKE, Arthur Roy, D.F.H.
FRASER, William, M.SC.(ENG.)
GAZZANA-PRIAROGGIA, Paola, DOTT.ING.
GREGSON, William Derek Hadfield, D.F.H.
HASLETT, Roy William George, B.SC., PH.D.
HEWITT, Harry
KIRKLAND, Eric
LEATHER, Arthur Johnson
LYNCH, Arnold Charles, M.A., B.SC.
NELSEY, John, B.SC.(ENG.)
NETTELL, David Francis, B.SC.
PALANDRI, Giuseppe Luigi, DOTT.ING.
STANNARD, George, B.SC.(ENG.)
STRONG, Clifford Charles
THOMAS, Eric Charles
WILLDER, Group-Capt. Kenneth Burnett Shelton, B.SC., R.A.F.

Associate to Associate Member

BODDY, John Gill, B.A.
CLARKE, Boyd Anthony, B.SC.
COCHRANE, Charles Alexander, M.A.
HALFTER, Nicholas Andrew
HARWOOD, Thomas Fairfax, B.A.
HEATHER, Kenneth Thomas, M.A.
IDLE, Allan Ellis, B.SC.(ENG.)
INCE, Cecil Raymond Sidney, M.A.
KELLY, John Philip, B.SC.
KING, Maurice James, M.A.
KIRBY, Harry Ashley, B.SC.
LAMOTTE, Gerald William Lewis, M.A.
MATTHEWS, Percy Ira Shearn, B.SC.
SCOTT, Godfrey Frank, M.A.
SYMONS, James Michael Dalrymple, O.B.E., M.A.
WALSH, Raymond, B.SC.

Graduate to Associate Member

AMBROSE, Frederick Arthur, B.SC.
BAGCHI, Chandra Nath, B.SC., B.E., M.SC.(ENG.)
BRAZENELL, Clement William
BROWN, Alfred Herbert
BROWN, William
CHANDLER, Edward Anthony
CLIFTON, Norman Haig
DAVIES, Alun, B.SC.
DOWN, John Otto
ELLIOTT, Ralph Basil
FLETCHER, Anthony Thomas
FOWLER, Kenneth Thomas
FUANGRABIL, Lt.-Cmdr. Snit, B.SC., R.T.N.
GARDINER, David
GETGOOD, Ronald Arthur Stanley, B.SC.(ENG.)
GHAI, Bal Krishan
GREEN, Eric
GREEN, Raymond Eric
HANKEY, Ernest Kenneth
HILDRED, Cedric Austin
HOCART, Hamelin James
HODGES, Graham John
HOPE, Leonard Vaughan
JONES, Robert Alan
LEE, Roy Albert
LISTER, James William
LOUKES, Harry, B.SC.(ENG.)
LOWE, Bryan
MACDERMOTT, Robert Terence
MACHOWICZ, Joseph Tadeusz, B.SC.
MCLACHLAN, John McCallum
MANN, Dennis Gordon, B.SC.(ENG.)
MANNS, Leonard, M.A.
MINTO, Alan Malcolm Greenfield, B.SC.(ENG.)
MORGAN, David Bertrey
MORRIS, Philip Arthur Crowley, B.SC.
NAGARKATTI, Anand Shripad
NAYLOR, Eric
OLLINGTON, David Reginald
PADDOCK, William Geoffrey
PEART, Norman Eli
PEGRUM, Robert Leonard
POPPLE, Gerald Banks
PORTER, Jack Wells, B.SC.(ENG.)

Graduate to Associate Member (continued)

POWER, Brian Daniel
RAHIMTOOLA, Amirali Fazal Ibrahim
READ, Roy William
REAR, Robert Morgan, B.SC.
RHODES, Frederick Michael Whitley, B.SC.(ENG.)
SMITH, Archibald Wallace
STACHERA, Henryk Stanislaw, B.SC.(ENG.), PH.D.
SUMMERS, Rodney Leslie
SYDNEY-MCCRUDDEN, Francis Donald
THOMPSON, Paul Stanley, M.SC.(ENG.)
TODD, Robert Frederick
VAN GEYZEL, Richard Bernarr
VARLEY, Keith, B.SC.
VICKERS, Donald Thomas, B.SC.(ENG.)
VINCENT, Albert Walter Henry
WEBB, Herbert Henry, B.SC.(ENG.)
WILLIAMS, Donald, B.SC.
WILLIAMSON, John

The following elections and transfers approved by the Council of The Institution are effective from the 2nd March 1961

ELECTIONS: 1st LIST

Graduates

ALEXANDER, Capt. Robert John, B.SC., R.E.M.E.
ANSARI, Mohammad Amir, B.SC.
BEATTIE, William Charles, B.SC.
BIRD, Frank George, DIP.TECH.(ENG.)
CASTLE, Anthony George
CHANDLER, Kenneth
CRAMB, John Allan, B.A.SC.
CRAMPTON, Felix Jeremy Philip, B.A.
DE SOUSA, Armando Mariano Joseph, B.E.
EDEBOR, Benjamin Okhuorobo Edison
EL-SAAD, Sahib Salim, B.SC.
GILLARD, Michael Peter, B.SC.
GREEN, Tony Alan, DIP.TECH.(ENG.)
GUMMER, Gerard Timothy John, B.SC.(ENG.)
HANDFORD, Michael Phillip
HARGRAVE, Peter Hugh, M.SC.
HOMBURGER, Ernst Raphael
HUGHES, Kenneth Alan, B.SC.
JACKSON, George, B.SC.
JACOBSON, Denny Peter, B.SC.(ENG.)
JONES, David Kenton
KILCOYNE, John Gerard, B.E.
LACEY, Edward Ernest
LAPIN, Avrum Issor Eli, B.ENG.
LESTER, Robert
LIDGARD, Geoffrey, B.SC.
MCCLEAN, Arthur John
MEIMERY, Seif Salem Seif, B.SC.
MILES, Derek
MILLER, Stanley Gordon, DIP.TECH.(ENG.)
MORAN, Peter Thomas, B.A.
MUHLBACHER, Hellmuth, DIPL.-ING.
NORSA, Michael Anthony, B.E.
PEDDER, Donald Austin Grant, B.SC.(ENG.)
PUGH, Harold John Harwood, B.A.
ROGERS, Peter Vercoe, B.SC.
SKELLY, Thomas William, B.E.
TAKO, Sandor Laszlo, A.R.C.S.T.
TUNNER, Alexander, B.A.SC.
TURNER, Maurice James, B.SC.
TWAITES, Stanley Walter
UPSON, Michael Victor, B.A.
WESLEY, Michael Andrew, B.A.
WRIGHTE, John Edward, DIP.TECH.(ENG.)
YALGINALP, Emin Alp, M.S.E.E.

Students

ADAMS, Charles Frederick
ADAMS, Philip John
ARMES, David John
ARMSTRONG, Ralph
ASH, Richard John
BARTRAM, Michael Charles
BAWDEN, Keith Henry
BELL, Malcolm Calvert
BHAGAT, Himatlal Bhikhubhai
BONE, Michael Sylvester Swinden
BOSWELL, Robert Frank
BOUGHTON, Peter
BUDD, David
CHEAH, Bin Seng
CHIDGEY, Leslie Arnold
CLAY, Leonard John
CLEMENTS, Stanley James
CLOSS, Gordon David
COCKRILL, Leslie William Scott
COHEN, Albert
COLE, Trevor Anthony
CONNOLLY, Malcolm Holmes
COOPER, Robert Francis
CORP, Philip James Gladstone
COZENS, Gareth Rees
CRAVEN, Gerald
CROSS, George Elderton
CUMMINS, Trevor Charles Laurence
CURTIS, Michael Ian Melville
DALBY, David Christopher
DANBY, John Roger
DE VILLIERS, John Neil
DEVLIN, John James
DILKES, Roy
DOMUN, Mohammad Khan
DURHAM, Robert
ENGLISH, Stanley Victor
EVEREST, Frank Geoffrey
FERGUSON, Leslie
FISK, Douglas Keay
GHANI, Usman, B.SC.
GIBBS, David
GOLDER, Mabel Ann
GRAY, Derek Kenneth
GREGORY, Richard John
GRIFFITHS, Donald Thomas
GRIMSHAW, Brian Reginald
GULATI, Sat Pal
HADJI-MICHAEL, Roger John
HALLETT, Roger
HARLEY, Paul Stuart
HAYTER, Francis Charles
HEATHCOTE, Malcolm
HERMON, Frederick Brian
HOLLIDAY, Ian Eric
HOLYOAKE, Lance
HOOD, David Charles
HOOPER, Lennard
HORNAGOLD, John Clifford
HOUTRIS, Anthony John
INNISS, Ricardo Enrique
JACKMAN, David
JARVIS, J/T Michael Roy
JEFFERIES, Michael John
JINSIWALE, Shridhar Dattatrya, B.E.
JOHNSTON, Robert Arnott, A.R.C.S.T.
KHAN, Tariq Talha Faruq
LENNOX, Barry
LEWIS, Adrian Sinclair
LEWIS, John Robert
MACKENZIE, John Dawson
MARCH, Anthony David Nelson

Elections and transfers (continued)

Students (continued)

MARSHALL, Michael John
MILSOM, Peter Roger
MITCHELL, Eric
MOORTHY, Ponnudurai Sambantha
MORGAN, Hywel Gwyn, B.SC.
MORTIMER, Derek Roy
NANDI, Himangsu Bhushan
NEENAN, William Patrick
NOWELL, Stephen John Alwyn
OJI, Theophilus Ifeanyichukwu
PERERA, Samitha Tharindra
PRIESTMAN, Terence John
RICHARDS, David Gordon
RIGBY, Gerald Peter
ROBERTS, Bernard
ROBINSON, Peter Howard
ROGATI, Francis Anthony
ROUNCE, William Jabez
ROWLINSON, David
ROXBURGH, John
SAWYER, Derek Miles
SAXTON, David Michael
SKERMER, Michael John
SLOLEY, Roger Wilkinson
SMERDON, Roger George
SOUTHERN, Ronald
STAVELEY, Kenneth
TARGETT, Edward Leonard
TAYLOR, Peter Arthur
TEICHNER, Thomas
THOMAS, Michael, B.SC.
THURSTON, Roger William
WALSH, George Joseph
WARDLEY, Brian Patrick
WEMEGAH, Julius Caesar Yao
WHITE, Edward John
WHITE, Neil
WILKINS, Robert
WILSON, David John
WYATT, Arthur George
YOUNG, Richard David

TRANSFERS: 1st LIST

Student to Graduate

ABROOK, George Edward
AGU, Louis Anidielo
ASHBY, Gerald Terence, B.SC.
BAIRSTOW, Jeffrey Noel, B.SC.
BALDWIN, David Arthur
BECKINGHAM, Brian Francis, B.SC.
BELL, Raymond, B.SC.(ENG.)
BRANSON, John, B.SC.
BRIERLEY, Anthony Herman, B.SC.
BROWN, Lt. Michael Edward Cyril, B.SC.(ENG.), R.N.
BULL, Donald Malcolm, B.SC.
BURTON, Henry
CHAPLIN, Ivan Cecil, DIP.TECH.(ENG.)
COLLINS, John Stuart, B.SC.
COOPER, Alan Cadmore
CRANSHAW, Arthur James
DALE, Anthony Peter, B.SC.
DAWSON, Michael John Groombridge
ECONOMIDES, Dionysios Gregoriou
FOY, Kenneth Frank
GABRIELS, Kenneth
GEORGE, Enyr
GILLANDERS, Robert
GOLDING, James Andrew, DIP.TECH.(ENG.)
GOLDSMITH, Michael John
GOSLING, John Buxton, B.SC.
GOTH, Diana Raby
GREENWOOD, David
GREW, Richard John McIlroy, B.SC.
HALL, John
HILL, John Michael Hughes, DIP.TECH.(ENG.)
HOOD, Ronald John
HUNT, Peter
JALALUDDIN, Zainuddin
JARVIS, William Anthony, DIP.TECH.(ENG.)
JOHNSON, Colin Peter
JONES, Wyndham
KINGSTON, Peter Hael, B.SC.TECH.
LANG, Terence, B.SC.
LAWSON, Robert Keith, B.SC.(ENG.)
LEYLAND, Bryan William
LINES, David, B.SC.
LOIZIDES, Andreas Georgiou, B.SC.(ENG.)
MCEVOY, Nicholas Eugene, B.ENG.
MAJUMDAR, Dipak, B.E.E.
MEHTA, Harshad Ishvarlal
METTANANDA, Asoka
MICHAEL, Ethelbert Victor
MOONEY, Roy Marshall
MOORE, Bryan
MORGAN, Thomas Geoffrey
MORRIS, John Henry
OWENS, Victor Thomas
PARAMESVARAN, Thamothalampillai Vaithilingam
PENDLEBURY, Joseph
PIGOTT, Peter Malcolm
PILFOLD, David, B.SC.
PILKINGTON, Donald James. B.SC.
POTTER, Eric Frederick
POWLEY, John Robert
PRICE, Nicholas Nadine Aitken, B.SC.
QAMARULLAH, Muhammad
QUINN, Anthony
REID, Bernard Edsell
REILLY, Bernard Colin, D.L.C.
ROLFE, Derek Sidney
SAMARAKKODY, Upali
SAUNDERS, Trevor James
SHACKLETON, Desmond Ebenezer, B.SC.
SHORE, William, B.SC.
SHROPSHALL, Peter Edward
SMITH, Alan
STEVENS, John, B.SC.
SURMAN, Colin Roger, B.SC.(ENG.)
TAYLOR, Frank Edward, M.SC.
TEN KLEY, Willem Berend
THAYANANDARAJAH, Somasundram
THOMAS, Richard Vincent, B.SC.
THOMAS, Stuart
THOMPSON, Brian Henry
THOMPSON, John Douglas, B.SC.
TIBBENHAM, William Percy
WILDE, Neville Arthur James, DIP.TECH.(ENG.)
WILLIAMSON, Roger Brian, B.SC.
WOOD, Ivor Thomas
WOOLLEY, Peter Maxwell
WRIGHT, Robert Frederick John, DIP.TECH.(ENG.)
WRIGLEY, David
YOUNG, Arthur

ELECTIONS: 2nd LIST

Graduates

DASGUPTA, Kajal Kanti, B.SC.(ENG.)
DAVIS, Peter Hugh, B.SC.
HARE, Michael John
HEAVISIDE, Leslie
JEFFERSON, Howard, B.SC.
JOHNSON, Richard Harold, B.SC.
MACDONALD, Ronald, B.SC.
POLLARD, Arthur, DIP.TECH.(ENG.)
SMITH, Norman Ellison, B.SC.
SMITH, Robert William George
TAYLOR, Leo Bernard, B.SC.(ENG.)
TOWNER, Robert Frederick Stanley, B.SC.(ENG.)

Students

BRETT, Aubrey, B.SC.(ENG.)
CHARLTON, Richard Stanley
CHEESMAN, Colin John
CHURCH, William Frederick
COTTINGHAM, Donald Malcolm
CRITCH, Martin Lewis
DHILLON, Charan Singh
EMERENINI, Paul Shimobi
FAIRFOUL, Peter
FOREMAN, Roger Julian
GODINHO, Norman
GUPTA, Salil Kumar, B.SC.
HADWIN, Leslie
HARVEY, David Desmond
HEAVISIDE, John Wilson
HORNE, Nigel William
HORROCKS, Frederick John
HUGHES, Brinley
HUSSEIN, Syed
JAYAWARDENE, Tissa Anthony Perera
JOHNSTON, Thomas, A.R.C.S.T.
JONES, Robert John
JONES, Roger Corris
KELLY, Roger Horton, B.SC.
KEYTE, Brian Henry
MADDOX, Brian Charles
MANSFIELD, Roger
NEAL, Richard John
O'HARA, James
OLADIMEJI, Olatunji Oladapo
OVADYA, Silvio Yasar
PITCHER, Roy Arthur
POULETT, Anthony
PRITCHARD, Brian Gordon
RANDALL, Stuart Jeffery
RUSHTON, Nigel John
SISNETT, Jeremy Bertrand
SKIRROW, Antony John
TEOH, Chin Koon, B.SC.(ENG.)
WAKEFIELD, Keith Frederick
WARRINER, Alan Victor
WONNACOTT, Ralph Edward
WRIGHT, Tony David

TRANSFERS: 2nd LIST

Student to Graduate

BEANEY, Michael Edward
BRUCE, Peter, B.SC.(ENG.)
CAMPBELL, Kenneth Scott
CHAPMAN, Peter David, B.A.
CHARLTON, Ian John Austin
DALRYMPLE, Joseph, A.R.C.S.T.
DRAKE, John Malcolm
DYKE, John Roger, B.SC.
FORSTER, John
GARRETT, John Mansell, B.SC.
GILBERTSON, Geoffrey Roger, B.SC.
GOVENLOCK, Terence Edmund, B.SC
GRANGER, Murray James
HANLON, Brian Leslie
HARVEY, Michael Robert, B.SC.
JEBSON, Derek
KIRK, David William
KNOTEK, Stenek
LANG, Harvey Graham
LEWIS, Roy Frank, DIP.TECH.(ENG.)
LONGLEY, David, DIP.TECH.(ENG.)
LOWDEN, Jeremy Lawrence, DIP.TECH.(ENG.)
MCRAE, Ian Nelson
MISRA, Krishna Kumar, B.SC.
OAKES, Martin, B.ENG.
PAGE, George Graham, B.SC.(ENG.)
PARIKH, Praful Sakerlal, D.F.H.
REID, Ian McLeod, B.SC.
ROWE, Barry, B.SC.
SPENCE, Edwin Wimperis, B.SC.
TWAITES, Brian Peter
WHELAN, Maurice, B.E.
WILLIS, Thomas Glanville, B.SC.
WORTH, Alan
YATES, Albert

British Nuclear Energy Conference

DETAILS of four forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the quarterly regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1961

APRIL 17–18 *Monday–Tuesday*

Sponsoring society: The Institute of Physics and The Physical Society
Place of meeting: University of Birmingham

Conference on NUCLEAR PHYSICS. Information on contributions and arrangements may be obtained from Dr. G. D. Burkhardt and Dr. P. M. Rolph at the Department of Physics, Birmingham University

APRIL 21 *Friday* (5.15 p.m.)

Sponsoring society: The Institute of Physics and The Physical Society
Place of meeting: University College, Aberystwyth, Wales

EUROPEAN CO-OPERATION IN NUCLEAR RESEARCH G. R. Evans

APRIL 24 *Monday* (5.30 p.m.)

Sponsoring society: Institution of Chemical Engineers
Place of meeting: Grand Council Chamber, Federation of British Industries, 21 Tothill Street, London S.W.1

DEVELOPMENT OF FLUID-FUEL REACTORS A. M. Weinberg

MAY 11 *Thursday* (7 p.m.)

Sponsoring society: The Institute of Physics and The Physical Society
Place of meeting: Liverpool University

FUNDAMENTAL PARTICLES Prof. J. M. Cassels

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH MARCH 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	930	9722	2	1
£2 to <£5	2377	6566	9	4
under £2	31130	16440	10	3
		£48595	4	8

HONOURS CONFERRED ON MEMBERS

IN the list of New Year Honours and Distinctions published on p. 127 of the February 1961 *Journal*, the following appointment was omitted:

KNIGHT COMMANDER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Tyler, Maj.-Gen. L. N., C.B., O.B.E., B.SC.(ENG.) (*Member*)

ANNUAL GENERAL MEETING OF THE INSTITUTION

THURSDAY, 18TH MAY 1961, AT 5.30P.M.

NOTICE is hereby given that the **Annual General Meeting of The Institution of Electrical Engineers** will be held on Thursday, 18th May 1961, at 5.30p.m., at the Institution Building, Savoy Place, London W.C.2, to receive and consider the Accounts for the year ended 31st December 1960, and the Annual Report of the Council, and to elect Auditors.

Copies of the Accounts and Report (which will in due course be published in the *Journal*) can be obtained on application to the Secretary about ten days before the date of the meeting.

By order of the Council,
W. K. BRASHER
Secretary

LECTURE BY MR. J. A. RATCLIFFE

MEMBERS are reminded that the Annual General Meeting on the 18th May 1961 will be followed by a lecture on 'Experimental investigation of space', by J. A. Ratcliffe, C.B.E., M.A., F.R.S., MEMBER.

NOMINATIONS FOR VACANCIES IN THE COUNCIL OF THE INSTITUTION

THE following brief biographical details of the Council's nominees for vacancies arising in the Council on the 1st October 1961 are set out for the information of members. A nomination circular is enclosed with this issue of the *Journal* to all Corporate members and Associates.

PRESIDENT (*one vacancy*)

G. S. C. LUCAS, O.B.E., F.C.G.I. G. 1928, A.M. 1930, M. 1934. Director and Chief Engineer, Associated Electrical Industries (Rugby) Ltd. Council (1950–52, 1953–56; Vice-President since 1956); Rugby Sub-Centre Committee (Chairman 1945–47); Wireless Section Committee (1938–41); service on all principal committees of Council.

VICE-PRESIDENTS (*two vacancies*)

A. H. MUMFORD, O.B.E., B.SC.(ENG.). S. 1922, A.M. 1930, M. 1941. Engineer-in-Chief, Post Office. Council (1952–55, 1956–58; Vice-President since 1958); Wireless Section Committee (1937–38; Vice-Chairman 1941–42; Chairman 1945–46; service in various capacities 1948–51, 1952–55); service on all principal committees of Council; Students' Lecturer (1946–48); two papers published in the *Proceedings*; Radio Section Premium 1954 (joint award).

R. L. SMITH-ROSE, C.B.E., D.SC., PH.D., F.C.G.I. A.M. 1921, M. 1936. Formerly Director of Radio Research, Department of Scientific and Industrial Research. Council (1953–56); Student Section (Vice-Chairman 1916–17; Chairman 1917–18; Honorary Secretary 1918–20); Wireless Section Committee (1937–38, 1939–42; Chairman 1942–43); Radio Section Committee (1946–49); service on principal committees of Council; 19 papers published in the *Proceedings* (seven jointly); Students' Premium 1919; Wireless Section Premium 1926, and in 1939 and 1940 (both jointly); Duddell Premium 1943 (jointly); Students' Lecturer (1952–53); Vice-President, I.R.E. (U.S.A.) 1948; President, International Scientific Radio Union (1960 to date); Chairman, Postmaster General's Frequency Advisory Committee; Member, Pilkington Committee on Broadcasting.

HONORARY TREASURER (*one vacancy*)

C. E. STRONG, O.B.E., B.A., B.A.I. A.M. 1933, M. 1937. Manager, Radio Division, Standard Telephones and Cables Ltd. Council (1950–53, 1957–60); Honorary Treasurer since 1960; service on principal committees of Council; Radio Section Committee (1944–47; Chairman 1947–48); Informal Meetings Committee (1958–59).

ORDINARY MEMBERS OF COUNCIL

MEMBERS (*four vacancies*)

SIR ROBERT COCKBURN, K.B.E., C.B., M.SC., PH.D. A.M. 1940, M. 1946. Chief Scientist, Ministry of Aviation; formerly Controller of Guided Weapons and Electronics, Ministry of Supply (1956–59). Congressional Medal of Merit.

J. S. MCPETRIE, C.B., PH.D., D.SC. A.M. 1932, M. 1940. Director General of Electronics Research and Development, Ministry of Aviation. Wireless Section Committee (1938–41); Radio Section Committee (1949–52); Radio and Telecommunication Section Committee (Vice-Chairman 1955–57; Chairman 1957–58); Research Committee (1957 to date); 11 papers published in the *Proceedings* (seven jointly); Wireless Section Premium 1929, 1940 (jointly).

PROF. C. W. OATLEY, O.B.E., M.A., M.SC. A.M. 1946, M. 1950. Professor of Electrical Engineering and Fellow of Trinity College, Cambridge. Cambridge Radio Group Committee (1946–49; Chairman 1949–50); Radio Section Committee (1949–52; Vice-Chairman 1952–54; Chairman 1954–55); Research Committee (1954–57); Library and Museum Committee (1955–56); four papers published in the *Proceedings* (two jointly); Measurement and Control Section Premium 1954 (joint award).

Announcements to members (continued)

H. WEST, M.SC., M.I.MECH.E. G. 1930, A.M. 1931, M. 1939. Managing Director, Associated Electrical Industries (Manchester) Ltd.; Managing Director, A.E.I.–John Thompson Nuclear Energy Co. Ltd. Council (1956–59); service on principal committees of Council; North-Western Centre Committee (1941–44, 1948–51; Vice-Chairman 1951–53; Chairman 1953–54).

ASSOCIATE MEMBERS (*two vacancies*)

J. BROWN, M.A., PH.D., D.SC.(ENG.). Age 37. A.M. 1953. Reader in Electrical Engineering, University College, London. 20 papers published in the *Proceedings* (13 jointly); Radio Section Premium 1954, 1957 (joint award).

P. L. TAYLOR, M.A. Age 37. A.M. 1954. Section Leader, Automatic Control and Machines Section, Research Department, Associated Electrical Industries (Manchester) Ltd.; special lecturer, Manchester College of Science and Technology.

COMPANION (*one vacancy*)

THE RT. HON. THE VISCOUNT FALMOUTH. A. 1922, C. 1929. Council (1924–27, 1931–34, 1940–43); Honorary Treasurer (1955–58); Education and Training Committee (1955 to date); Court of Governors, Incorporated Benevolent Fund (1942–43, 1956–58).

NOMINATION

SUNDERLAND TECHNICAL COLLEGE—GOVERNING BODY

THE Council have nominated Mr. J. Christie, MEMBER, as their representative on the above governing body.

THIRD INTERNATIONAL CONFERENCE ON MEDICAL ELECTRONICS: 1960

THE *Proceedings of the Third International Conference on Medical Electronics*, which was held in London from the 21st to 27th July 1960, are being published in three parts. The prices (post-free) are £2 10s. for each part or £7 for all three. The titles of the parts and the months in 1961 in which they will appear are:

Part 1 Measurements in medicine and biology	mid-May
Part 2 Research and clinical applications	early in June
Part 3 Equipment, techniques and safety	late in June

Each part will be in a semi-stiff cover and will consist of about 200 pages. A volume title page and index will be supplied with Part 3.

The *Proceedings* are being published by The Institution on behalf of the International Federation for Medical Electronics.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

MEMBERS who may have to travel abroad are reminded that, in certain countries, reciprocal arrangements are in operation with engineering institutions for the extension of privileges to visiting members. The complete list of institutions concerned is as follows:

country	*institution*
Australia	Institution of Engineers, Australia
Austria	Österreichischer Ingenieur- und Architekten-Verein
Belgium	Société Royale Belge des Ingénieurs et des Industriels
	Société Belge des Électriciens
Brazil	Instituto de Engenharia
Canada	Engineering Institute of Canada
Ceylon	Institution of Engineers, Ceylon
Denmark	Dansk Ingeniørforening
Finland	Suomen Teknillinen Seura
	Tekniska Förenigen i Finland
France	Société des Ingénieurs Civils de France
	Société Française des Électriciens
Germany	Verein Deutscher Ingenieure
	Verband Deutscher Elektrotechniker
Holland	Koninklijk Instituut van Ingenieurs
Iceland	Association of Chartered Engineers in Iceland
Ireland	The Institution of Civil Engineers of Ireland
India	Institution of Engineers, India
Italy	Associazione Elettrotecnica Italiana
	Associazione Nazionale Ingegneri e Architetti Italiana
Japan	Institute of Electrical Engineers of Japan
New Zealand	New Zealand Institution of Engineers
Norway	Norsk Elektroteknisk Forening
	Den Norske Ingeniørforening
Pakistan	Institution of Engineers, Pakistan
Portugal	Ordem dos Engenheiros
Rhodesia	Rhodesian Institution of Engineers
South Africa	South African Institution of Civil Engineers
	South African Institute of Electrical Engineers
	South African Institution of Mechanical Engineers
Spain	Instituto de Ingenieros Civiles de España
Sweden	Svenska Teknologföreningen
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein
Turkey	Turkish Engineering Society
United States	American Institute of Electrical Engineers
	American Institute of Chemical Engineers
	American Institute of Mining and Metallurgical Engineers
	American Society of Civil Engineers
	American Society of Mechanical Engineers
	Institute of Radio Engineers

The Secretary of The Institution of Electrical Engineers will gladly provide letters of introduction for members visiting these countries.

STUDENTS' QUARTERLY JOURNAL

THE March 1961 issue of the *Students' Quarterly Journal* contains two interesting articles on the general details of and transmission experience with the passive Earth-satellite Echo. In addition there are articles on a.c. traction rectifier equipments, Diesel railway locomotives, interference between communication and power circuits, the rising service, and the Schrage motor, as well as a report of a visit to Radiotelevisione Italiana and the usual Section reports and book reviews.

THE APPLICATION OF STANDARDS

A CONFERENCE of engineers and others concerned with the application of standards will be held in London on the 9th and 10th May 1961.

The first day of the conference will consist of plenary sessions at the Connaught Rooms, London, including papers on an integrated standards programme in the company, standards in product development (electronics), and standards in market research and sales. On the second day, at British Standards House, there will be three parallel sessions in the morning and afternoon to discuss such topics as the application of a standards system in a smaller company, standardization in fields where techniques are advancing rapidly, and standardization in a one-off and batch production company.

Further information may be obtained from the British Standards Institution, British Standards House, 2 Park Street, London W.1.

INTEGRATED DATA PROCESSING

A ONE-DAY conference on integrated data processing in Britain and America, held in February 1961, was so heavily oversubscribed that the organizers have arranged for it to be repeated on the 24th May 1961 in the Assembly Hall of Church House, Great Smith Street, Westminster, London.

The cost of tickets is six guineas each, which includes luncheon at St. Ermins Hotel, light refreshments morning and afternoon, and a copy of the European Productivity Agency Mission Report with which the conference is concerned.

The conference is being organized by the British Productivity Council in co-operation with the British Conference on Automation and Computation, the British Institute of Management, and the Institute of Cost and Works Accountants. Further information may be obtained from the British Productivity Council (IDP Conference), Vintry House, Queen Street Place, London E.C.4.

1961 BAIRD MEMORIAL LECTURE

THE Royal College of Science and Technology, Glasgow, announce that the 2nd Baird Memorial Lecture will be delivered by Prof. Martin Ryle, F.R.S., in the college on the 7th June 1961. The title of his lecture will be 'Exploring the universe with radio waves'.

AUTOMATION—MEN AND MONEY

MORE information is now available about the conference 'Automation—men and money', to be held at Harrogate from the 27th to 30th June 1961 under the aegis of the British Conference on Automation and Computation, which was announced on p. 53 of the January 1961 *Journal*.

The conference will begin with a plenary session on the 27th June at 9p.m. in the Royal Hall, Harrogate, when the speaker will be the Rt. Hon. The Viscount Hailsham, Q.C., Lord President of the Council and Minister for Science. Meetings relating to the four sections of the conference (economic aspects—internal to the firm; economic aspects—in the wider context; social aspects—internal to the firm; and social aspects—in the wider context) will be held simultaneously from 9.30a.m. to 4.15p.m. on the 28th and 29th June and from 9.30a.m. to 11a.m. on the 30th June. The meetings on the 30th June will take the form of case studies, and at a final plenary session Sir Walter Puckey, chairman of the conference, will review the proceedings. There will be an opportunity to discuss the sectional papers in the discussion groups that will immediately follow the sectional meetings. The conference fee (excluding hotel accommodation) is 11 guineas.

Further information may be obtained from Mrs. J. Hodson, Conference Secretary, British Institute of Management, 80 Fetter Lane, London E.C.4.

MACHINE-TOOL DESIGN AND RESEARCH

AN international conference on machine-tool design and research is to be held at the Manchester College of Science and Technology from the 25th to 29th September 1961. Papers will be read on recent researches in manufacturing methods, results of investigations into the behaviour and performance of machine tools, developments in the design and manufacture of machine tools and machine-tool control systems, and productivity and economics of machine-tool applications.

Enrolment forms and further information may be obtained from the Organizing Secretary, Mr. J. P. Mabon, Manchester College of Science and Technology, Manchester 1.

MANAGEMENT TRAINING

TRAINING in management at Ashridge College, Hertfordshire, includes four-week residential executive development courses (24th April–19th May, 26th June–21st July, 4th–29th September, and 30th October–24th November 1961); courses on financial knowledge for managers (29th May–2nd June and 12th–16th June 1961); and an annual study conference for senior training officers responsible for management training (9th–13th October 1961).

Further details may be obtained from the Principal, Ashridge College, Berkhamsted, Herts.

CRITICALITY CONTROL

AN international symposium on criticality control in chemical and metallurgical plant, organized by the O.E.E.C. European Nuclear Energy Agency in collaboration with Kernreaktor Bau- und Betriebsgesellschaft m.b.H., is to be held from the 2nd to 5th May 1961 at the Karlsruhe Nuclear Research Centre in Germany.

The symposium is intended for persons responsible for the criticality aspects of the design and operation of installations dealing with enriched uranium or plutonium, such as fuel-element fabrication plant, reprocessing plant, conversion plant for enriched uranium, or scrap-recovery plant. The programme will comprise 20 lectures by leading European and American specialists, together with discussions on both the fundamental principles and the practical applications of criticality control.

Further information may be obtained from O.E.E.C. European Nuclear Energy Agency, 38 Bd. Suchet, Paris 16.

Announcements to members (continued)

ELECTROMAGNETIC THEORY AND ANTENNAS

A SYMPOSIUM on electromagnetic theory and antennas will be held at the Technical University of Denmark, Copenhagen, from the 25th to 30th June 1962 and will be open to any interested person from any country.

Papers dealing with these subjects are invited: electromagnetic fields in anisotropic media, such as plasmas and ferrites; diffraction theory; scattering in random media; quasi-static electromagnetic problems; theory of broad-band antennas; and antenna pattern synthesis. 800–1200-word summaries of papers should be submitted by the 1st December 1961 at the latest to the Technical Programme Committee, Technical University of Denmark, Øster Voldgade 10G, Copenhagen K.

TRANSMISSION AND PROCESSING OF INFORMATION

IT is announced by the Institute of Radio Engineers that the international symposium on the transmission and processing of information, which was to be held at the Massachusetts Institute of Technology from the 6th to 8th September 1961 (January 1961 *Journal*, p. 54), has been cancelled because of an inadequate response to the call for papers.

AERO-SPACE NUCLEAR PROPULSION

AN international symposium on aero-space nuclear propulsion will be held in Las Vegas, Nevada, U.S.A., from the 23rd to 26th October 1961. Subject-matter for the symposium, which is sponsored by the Institute of Radio Engineers Professional Group on Nuclear Science, includes instrumentation, control systems, engine simulation, and engine dynamics in the aero-space nuclear propulsion and nuclear auxiliary power fields, as well as radiation and temperature effects on instruments and controls.

Further information may be obtained from P. M. Uthe, University of California, Lawrence Radiation Laboratory, Box 808, Livermore, California, U.S.A.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th February to 16th March 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

BURGESS, R. N. (New Plymouth, New Zealand)
COOPER, P. (Wellington, New Zealand)
DAVISON, R. C. (Wellington, New Zealand)
JENKINS, D. (Auckland, New Zealand)
LAETT, H. A. (Bremgarten, Switzerland)
SANDS, E. C. (Nassau, British West Indies)
SUTTON, F. W. (Nairobi, Kenya)
WOODWARD, J. L. (Christchurch, New Zealand)

LONDON REPORT

DISTRICT MEETINGS AT OXFORD

CHANGING STANDARDS IN A MODERN WORLD

AT the meeting on the 8th February 1961 at the Oxford headquarters of the Southern Electricity Board, Mr. M. J. L. Pulling presented his paper 'The development of Eurovision'. An article based on the author's Chairman's Address on this subject (delivered to the Electronics and Communications Section on the 28th October 1959 at Savoy Place) appeared in the February 1960 *Journal*, p. 96.

Mr. Pulling gave a very clear and comprehensive survey starting with the first pioneering efforts from Calais in 1950 and finishing with a peep into the future of Earth-satellite relay stations. He emphasized the importance of the standards conversion and pointed out that the original method, which was really in the nature of an expedient, was still being used; he cited an analogy of a microphone being suspended in front of a loudspeaker.

He said that there were difficulties in the way of producing a truly all-electronic video-conversion system, but he was nevertheless optimistic about the ultimate solution to the problem.

The line-standard problem

The discussion which followed Mr. Pulling's presentation was both lively and thought-provoking. Among topics raised was the vexed question of line standards. Mr. Pulling commented on each of the common European systems and said that the 405 standard still had many advantages, the 819 suffered serious shortcomings in practice as against its theoretical advantages, but that he was of the opinion that, bearing in mind the needs of international programme exchange, the 625 standard would be the proper choice today.

A vote of thanks was proposed by Mr. A. T. Bayliss and heartily endorsed by the meeting. Mr. D. Westwood was in the chair.

D. W.

AUTOMATIC WAREHOUSING

THE last meeting of the session was held at the Southern Electricity Board's showroom in George Street, Oxford, on the 8th March 1961, when Mr. W. J. Fry talked about 'Automatic warehousing'. He first described the basic principles whereby electronic equipment controlled an electrically operated storage system in such a manner that any selection of commodities was automatically delivered for packing in 15 sec.

After a short film showing an installation in an American drug warehouse in operation, he explained the various components and their relation. The equipment used transistors throughout; and the design, based on simplicity and stability to guard against mal-operation, was self-checking, with a feedback system. The electro-mechanical storage bays and conveyor system could be varied in form and arrangement to suit varying commodities or batches of commodities.

Consistent with the 'space age'

A binary code was used to allow a wide range of requirements to be punched on a single card, and the system could be coupled with existing electronic office equipment. Samples of the equipment were available for inspection.

There was a vigorous discussion. Mr. Fry dealt ably with the technical points and those concerning the economic aspect of application: the possibilities were fascinating and entirely in keeping with the 'space age'. The discussion was closed by the chairman, Mr. R. Carruthers, and Mr. A. J. Davis proposed a suitable vote of thanks which was heartily endorsed.

J. L. T.

EDUCATION DISCUSSION CIRCLE

MANAGEMENT STUDIES FOR JUNIOR ENGINEERS

Mr. G. S. C. Lucas was the opening speaker in the discussion on the above subject at the meeting at Savoy Place on the 20th January 1961. Dr. G. S. Brosan presided. Mr. Lucas stressed the need for management courses for engineers and pointed out that both the need and scope of these could be seen clearly as supplementary postgraduate courses. What was not so clear was that there were fundamental underlying principles that justified courses in management for engineers at undergraduate level.

Probably the greatest difficulty in making headway in management courses for engineers lay in attempting to work from the general to the particular. More progress could be made if the specialist courses were established at postgraduate level and the basic principles left to evolve.

More maturity required

The general discussion that followed brought forward viewpoints of both student and teacher of such courses. It was generally accepted that a more mature individual was needed to appreciate the subtleties of the subject, although the subject-matter itself was not necessarily at a high academic level. The term 'postgraduate in time but not in standard' was used by more than one speaker. The evening closed with a witty vote of thanks to the speaker from Prof. R. O. Kapp.

B. F. G.

ORDINARY MEETING

SILICON POWER RECTIFIERS

The paper selected for the meeting at Savoy Place on the 2nd February 1961 was a Utilization Section paper 'Silicon power rectifiers', the authors being Mr. A. J. Blundell, Mr. A. E. Garside, Mr. R. G. Hibberd and Mr. I. Williams, all of whom were present. A short review of the paper appears on p. 229.

The meeting was well attended and the President, Sir Hamish MacLaren, called on Mr. Blundell to present the paper.

The paper surveyed the principal aspects of the preparation, manufacture, design and application of silicon power rectifiers. Mr. Blundell described the silicon rectifier as the latest addition to the series of rectifiers based on the physics of the solid state, in which each successive type, starting from copper oxide, had brought a progressive improvement in the voltage per cell. The silicon rectifier, used over a wide range of voltage and current, would remain an established type for some years to come.

With the aid of coloured slides and diagrams the speaker explained the salient features of the paper in detail, mentioning particularly the preparation of single-crystal silicon, the reduction of the impurity level to below 10^{-9} and the techniques used to achieve the desired intrinsic properties. He then described the technicalities of manufacture, testing and rating of silicon rectifiers, emphasizing the proper interpretation of the two different types of reverse characteristic, one fatal the other non-fatal.

Operational characteristics and protection were also mentioned, together with typical examples of applications, such as electrolytic, traction, alternator excitation and aircraft work, in which the silicon rectifier possessed special advantages. Attention was called to the future importance in the power field of the latest device, the controlled silicon rectifier, while for further in the future, in particular where operation at higher ambient temperatures up to 500°C might be encountered, work was already in hand on high-energy-gap compounds such as silicon carbide and aluminium antimonide.

Technology in production

Maj. L. H. Peter, opening the discussion, recalled an earlier paper by the late Prof. C. L. Fortescue on crystal structures and said that it was extraordinary how much was seen by way of devices in use before we actually knew how they worked. A feature of the present development was the amount of help which the manufacturer required in the way of technical physics, metallurgy and special processes. He indicated a method of surge protection for silicon rectifiers, using a selenium rectifier in parallel as a surge suppressor. He stressed the need for developing a common nomenclature for this field of activity, especially in defining a cell's possibilities.

London report (continued)

Mr. J. E. Boul pointed out the ambitious task undertaken by the authors in dealing with a current range from 0·25 to 100 A, including both diodes and controlled devices. He commented on the reverse losses being 5–10% of the forward losses as cited by the authors and referred to the different protective and other treatment offered to small and large cells in engineering equipment. He emphasized the need for as much standardization as possible among these silicon devices.

Mr. A. Langridge showed some excellent slides of crystal material as seen under the microscope, describing various forms of structural imperfection and etching. He discussed thermal fatigue and the requirements for properly matching the expansion of the silicon with that of the copper base to which it was either directly or indirectly attached.

Mr. D. R. Coleman quoted silicon rectifiers available with peak working voltages higher than 600 V and peak inverse voltages better than 1 kV. Surface treatment and encapsulation were also mentioned. He was followed by Mr. R. A. A. Newman, who referred to surge-current ratings and junction temperatures, pointing out the effects of mechanical stress and thermal fatigue and outlining a quick temperature-cycle test that enabled diodes with weak mechanical properties to be eliminated at an early stage.

By this time the discussion had fairly got going, and speaker after speaker followed, covering practically all technical aspects of the subject, including such matters as switching problems in operating controlled rectifiers in series strings, protection by capacitors in parallel, parallel operation of diodes, insulation margins, radio interference, controlled silicon rectifiers inverting into inductive loads, and the differences between small jobs and properly engineered equipment. Finally, one speaker confessed to being involved in tests in which silicon rectifiers had been fired out of a shot-gun.

The authors reply

Mr. Blundell again opened in reply to the discussion, dealing most comprehensively with the many points raised. He stated that many of the diodes had reverse losses considerably less than 10% of their forward losses and that most of the diodes produced in manufacture were in the 600 V peak-inverse-voltage region; he considered that economics favoured derating and extra diodes in parallel rather than using short-circuiting switches for protection and that present creepage distances would be increased in diodes used in the heavy-current industry. The remaining points in the discussion were replied to by Mr. Hibberd.

As befitted a paper selected by the Utilization Section, Mr. J. Ferguson, its Chairman, proposed the vote of thanks. He looked to further stimulating results from research benefiting both the light-current and the heavy-current sides of electrical engineering and concluded by proposing a hearty vote of thanks which was carried with acclamation.

W. G. T.

BULLETIN OF THE SECTIONS

UTILIZATION

A.C. CRANE-HOIST CONTROL

THE title of the paper read at the meeting at Savoy Place on the 12th January 1961 was 'A new form of crane-hoist control using a 3 : 1 pole-changing induction motor', and the authors were Dr. O. I. Butler and Dr. V. Ahmad. A short account of this paper appears on p. 231.

In their presentation the authors pointed out that, whereas during the first quarter of the century the use of d.c. motors had been regarded as essential for the operation of the hoist motors of cranes, owing to the inadequate speed-control of a.c. induction motors for lowering loads, the increasing availability of a.c. supplies had subsequently led to an extensive use of the a.c. motor combined with resistance speed-control on both the raising and lowering motions. However, the performance of the a.c. machine had still been unsatisfactory compared with that of d.c. machines for such duty.

Significant developments, however, had occurred in the method of speed control of the a.c. machine, and, after considering these developments in relation to the general requirements of craine-hoist drives, the authors described the performance of an experimental machine consisting of a 3 : 1 pole-changing induction motor in conjunction with a single-phase autotransformer. This demonstrated that the needs of many crane hoists had been satisfied without undue cost and complexity of equipment and that a large reduction in the size and weight of the control gear had been achieved.

Battle of the systems

The discussion was opened by Mr. G. V. Sadler who, in referring to the importance of doing away with inching, pointed out that the present tendency in crane control was to change the torque/speed-characteristic curve from a nearly

vertical line per notch to a horizontal line, which was the principal factor influencing cost. He added that the form of control described by the authors, if adopted, was by no means out of the price range. Some people, he said, appeared to think that if d.c. motors were employed to drive cranes something was being obtained for nothing; they seemed to forget that the initial cost of a d.c. motor was nearly twice that of an a.c. machine.

One speaker joined issue in what he termed 'the battle of the terminals', stating that, if a job could be done with six of these on the motor instead of nine, that was the line that would be adopted. Another contributor, while discussing the high cost of a.c. speed controllers, made reference to the crane-makers' dream, which was to get rid of all contactors and resistors. The opinion was put forward that in its present form the authors' scheme was too complicated to be attractive.

All those listening to the d.c. and a.c. supporters in the discussion must have agreed with the Chairman, Mr. J. M. Ferguson, when, in proposing a vote of thanks to the authors, he remarked that the old long-drawn-out 'battle of the systems', which had initially been fought by many prominent and early members of The Institution, was still apparently undecided and had its respective and doughty champions even today.

R. H. R.

INDIA—TODAY AND TOMORROW

ONCE again the Section has ranged far for lecturer and subject for its Annual Lecture, and on the 10th May 1961 Dr. M. Datta will present to members interesting features of the supply problems in India.

Against the background of a vast population desirous of improving living standards, the pace of development must be high, and the part played by electricity-supply requirements has unquestionable importance. Dr. Datta will endeavour to show how the pattern is forming from the viewpoint of demand and supply of electrical power, and will describe the impact of the manufacturing and associated activities.

Energy and transmission

The availability of energy sources—water, coal and nuclear—is reviewed, and the limitations and prospects are examined. The attempts to co-ordinate planning and the formation of regional-grid schemes have affected the sizes of generating plant, both thermal and hydraulic. The nuclear side will, it is expected, be ultimately dependent on the use of thorium, which is in plentiful supply.

Dr. M. Datta

Transmission schemes are growing, and a supergrid linking the systems of the contiguous States is visualized. The character of the lower-voltage-line construction is dealt with. Since lightning effects are frequent, views on the forms of protection are expressed. On the distribution side, economics features largely, since the needs are rural and attempts are being made to use indigenous materials, which have led to afforestation schemes.

Research and manufacturing

Research into the development and utilization of energy sources, suitable equipment and manufacturing facilities form part of the planning which has been entrusted to a specially created Commission. On the manufacturing side, the building up of an industry for providing capital and consumer goods is proceeding quickly, and the contribution from British manufacturers is outlined.

Dr. Datta, speaking of the future, sums up by stating that India's future problems will be great, but enthralling and stimulating. Members of the Supply Section look forward to hearing the story to date.

The lecturer

Starting with a bent towards mathematics and physics, Dr. Datta spent periods in the United Kingdom obtaining practical engineering experience, furthering his academic work and gaining knowledge of the supply side. Returning to India, he joined the West Bengal State Electricity Board, later going abroad to study hydroelectric-power schemes. He is now chief engineer of the Board and has undertaken an extensive variety of projects.

He has written many scientific papers and as an active member of The Institution has furthered its work. He is Chairman of the Calcutta Branch.

His wide knowledge of supply problems and those particularly related to his country's needs should provide an interesting and informative lecture.

F. C. W.

ARC TAMING

THE problem of power arcs and their behaviour in relation to bushings and line insulators caused a fair attendance at Savoy Place on the 1st February 1961 when, under the Chairmanship of Mr. J. E. L. Robinson, Dr. A. E. Guile read his paper 'The protection of high-voltage insulators from power-arc damage'. This paper is reviewed on p. 230.

The author outlined the studies made of arc movement under magnetic effects and the influence of wind. From the deductions made, recommendations on the spacing of the protective gaps and their form were proposed, service experience of arc damage was examined, and views were expressed on the economic factors involved.

Protection and the failure rate

Describing himself as a humble contractor, Mr. N. G. Simpson commented on the statistical aspects of the service experience quoted, pointing out that particularly oversea the rate of failure might be higher than indicated, since records were sparse; moreover, seasonal effects should be taken into consideration. The failure rate should be reduced. The trend of overhead-line work caused the reliability of systems to grow in importance and called for improvements in protection.

He directed attention to unearthed constructions, with their enhanced insulating features, which could establish higher reliability. While on earthed systems the protection provided by electrodes was imperative, the forms suggested by the author could prove helpful at the lower voltages, but he was anxious to hear the supply engineers' views.

On the service experience quoted, Mr. D. F. Oakeshott considered that, for installations where the voltage exceeded 66kV, since the protective gaps were set well clear of the bushings, the type of damage envisaged by the author could not occur.

He conceded that such gaps were intended for protection against lightning effects. In supporting the recommendations for 11kV systems and in making a number of points relating to constructional features, he brought out the economic aspects but concurred with Mr. Simpson's vindication of the costs involved.

Mr. Oakeshott favoured the application of the type of arcing horn and ring suggested and called attention to the difficulties of mounting them on bushings on outdoor circuit-breakers where limited phase- and pole-clearances existed; Mr. R. N. Buttrey and Mr. F. C. Walmsley also mentioned this point.

Mr. D. J. Miller asked for further information on the behaviour of pin-type insulators and inquired whether any conclusions had been reached on the comparative performances of glass and porcelain pin-type insulators. He expressed alarm at the suggestion that insulated systems should be encouraged.

Service observations

Commending Dr. Guile's research during a university postgraduate study, Mr. L. Gosland considered it a useful example of practical thinking. The work done on the electromagnetic movement of the root of the arc and related aspects was invaluable. The Chairman inquired how far the methods of initiating the arc and the damage resulting related to observations in service.

Dr. Guile dealt very adequately with the discussion and gave some support to the views of Mr. Simpson on the behaviour of unearthed systems. On the protection of extra-high-voltage systems, he agreed that, although very short times of fault condition existed, the possibility of damage could not be disregarded.

As to the limitations created by possible encroachment on clearances, particularly with outdoor oil-circuit-breaker tops, modifications could possibly be introduced that would still permit the basic recommendations to be met. Replying in detail to the points on pin-type insulators, he referred Mr. Miller to some earlier work on the relative performance of glass and porcelain.

The competent replies which Dr. Guile provided, together with his presentation, gave much pleasure to his listeners and they warmly recorded their reaction. F. C. W.

ELECTRONICS AND COMMUNICATIONS

APPLICATION OF MILLIMETRE WAVES

ON the 25th January 1961, a lecture on 'Generation and amplification in the millimetre-wave field' was given at Savoy Place by Mr. W. E. Willshaw, who prefaced his survey by saying that, in his opinion, communication systems and radar would depend for many years on the extrapolation of techniques used at longer wavelengths. He would therefore concentrate on generators designed for other purposes, e.g. spectroscopy, where the search was always for shorter and shorter wavelengths and generation of power was enough in itself.

As he said, this was a welcome simplification of the problem, because no successful amplifiers had yet been built for operation at wavelengths in the range he discussed. After emphasizing the attendant difficulties of the inherently small dimensions of devices operating at millimetre wavelengths, the lecturer presented a comprehensive review of devices giving useful power output at wavelengths down to 1mm.

Oscillators depending on known interaction processes between electron beams and periodic structures and resonators gave more power than any other device, even though the

attraction of dispensing with the circuit and its attendant problems of power dissipation and fabrication had led many experimenters to study direct radiation from beams, periodic and undulating beams in non-periodic waveguides, and plasmas, arcs and molecules as alternatives to the circuit as an energy store and frequency-determining element.

Thus it seemed that copper continued to be essential for the efficient generation of coherent power at any frequency from zero upwards. Perhaps the most outstanding of all the tubes described were the backward-wave oscillators of Convert. One of these gave 50mW at 2mm with tuning over 5% by adjustment of beam voltage, and the smaller version 1mW at 1mm with 15% tuning.

Summing up, Mr. Willshaw thought that further progress in this field was more likely to come by extrapolation from present knowledge than by a break-through into a new technique.

Formulating laws

Prof. A. L. Cullen said that the lecturer had given a beautifully balanced account of a field full of ideas and solid achievement, and commented that the tuning range of the Convert tube was equal to the whole spectrum of frequencies below 40Gc/s. He supported the opinion that extrapolation was likely to be the most profitable approach to wavelengths around 1mm, and suggested that there might be a law 'volume $= (\lambda/A) + (B/\lambda)$' which would apply below that wavelength with the constants A and B properly chosen.

Mr. J. Dain said that, although scaling factors seemed to indicate that it would be possible to generate power of the order of tens of watts in the region of 1mm, it was almost certain that such properties of material as thermal and electrical conductivity would intervene and so prevent us from obtaining this most desirable result. Would our advance therefore depend on the evolution of new materials and technology?

Mr. L. Lewin suggested that there was a philosophic possibility which might be considered at leisure, and that was to abandon preconceived notions about the necessity to generate and use coherent power in the millimetre-wavelength range and to attempt the use of quanta, because one could do quite a lot with light and generate it with reasonable efficiency. He acknowledged that this might be very difficult in the range of wavelengths between 0·1 and 1mm.

Mr. R. W. White said that his appetite had been whetted by the menu set before him, but when might he dine? As a communication engineer, he would have liked to know how life would be related to wavelength—it seemed to be directly proportional.

No guesses hazarded

In reply, Mr. Willshaw said he was sure that Mr. White would be satisfied in due course with both characteristics and life. As to the availability of amplifiers for communication in the band around 2mm, he could not estimate when they would be built with characteristics to suit Mr. White. Commenting on Mr. Dain's question on the effect of thermal and electrical conductivity, the lecturer said that he would hazard no guess as to the ultimate effect on starting currents and operating power level, but he saw no fundamental reason why these should prevent generation of useful power at wavelengths appreciably shorter than those he had considered.

Thanks to the speaker were proposed by the Chairman, Mr. T. B. D. Terroni, and carried with acclamation. E. B. C.

MEASUREMENT AND CONTROL

FILMS FOR SPECIALISTS

On the 7th February 1961 the Section met jointly at Savoy Place with the Electronics and Communications Section for a lecture and discussion on the magnetic properties of thin films (the kind used in computers). The lecturer, Mr. E. M. Bradley, assumed that his audience were all specialists—he was not far wrong—and plunged directly into the mysteries of the subject.

Within two minutes he was showing the odd shapes of hysteresis loop that these films could exhibit and demonstrating the shapes on an oscillograph in case anyone was incredulous. The attraction of these films for computer designers was that their magnetization could be reversed in less than 10^{-9}sec; the problem, in obtaining this very fast response, was to make the magnetic vector rotate without the appearance of domain structures and to avoid poising the magnetization in unstable equilibrium.

Coherent rotation was ensured, said Mr. Bradley, by using areas which formed part of a continuous sheet rather than by producing separate areas through masking or etching away the intervening material (in the discussion several speakers disagreed with this and advocated the use of separate spots).

Employing these films in a two-dimensional store in a computer was more difficult than it might appear. The type of drive used for ferrite-core matrices, with two driving fields along the same direction, was impracticable because it set close limits to the permissible coercivity of the material. Systems had been developed in which one of the selecting fields was applied in the 'hard' direction; this allowed a tolerance of $\pm 20\%$ in coercivity but required the 'easy' direction to be known to within $\pm 2°$ for one system or $\pm 5°$ for another.

Mr. Bradley and his colleagues had achieved this precision, but only by abandoning the usual nickel–iron film on glass in favour of an as-yet-undisclosed alloy deposited on aluminium.

Many questions

This introduction triggered a remarkably brisk discussion in which 12 speakers took part, some of them several times, and Mr. Bradley was kept hard at work answering questions.

Dr. C. W. E. Grigson had succeeded in controlling coercivity by evaporating powder supplied continuously into a hot crucible and taking care that the vacuum was good, but he thought that Mr. Bradley's side-stepping of this problem was useful. He asked about the origin of the uniaxial anisotropy of the films, but it seemed that the change from glass to aluminium as a substrate had thrown no light on it.

Mr. A. S. Young, genially pugnacious, and Dr. J. H. Stephen discussed the production of films by chemical or electrochemical methods instead of by evaporation. Dr. Stephen found the properties greatly affected by the crystal size of his copper substrate, while Mr. Young reported good results with alloys containing chromium or manganese and having a small crystal size (less than 30 Å).

Mr. Bradley was doubtful about the purity of the films made by these methods; Mr. Young said that the 5% of phosphorus in his films was 'not an impurity', but he didn't say why. Mr. Bradley's films were thin (about 1000Å). Mr. A. C. Lynch asked about the possibility of using rolled films of a few microns thickness; he received some encouragement from Dr. Stephen, but none from Mr. Bradley.

Accused by another speaker of using extravagantly large driving fields, Mr. Bradley gave detailed figures of the currents needed; he thought that some increase of coercivity in the 'hard' direction, if it eased the tolerances, might be a good bargain. Dr. D. M. Taub asked about the equivalent circuit of a unit in a computer store; Mr. Bradley decided—apparently impromptu—that it was nearly a pure inductance.

Mr. C. G. Garton, Chairman of the Section, thanked the lecturer—an easy task, because so many people had so obviously been thoroughly interested.

Opinions wanted

Several members of the Section Committee know why the attendance at recent meetings has increased so markedly; unfortunately they all give different reasons. It may be simply the policy of having lectures rather than formal papers; it may be that the subjects thereby become of more general interest, since there is a wider choice available when there is no need to obtain a formal paper on it; or it may be the result of holding meetings jointly with other Sections. Comments from members of the Section will be welcome. A. C. L.

News from the Centres

NORTH STAFFORDSHIRE SUB-CENTRE

The powers unseen

The Sub-Centre had the pleasure of a visit by Mr. O. W. Humphreys, a Vice President, on the 16th January 1961 at Stafford, when he conveyed greetings from the President and referred briefly to the report of the Special Advisory Committee of which he was Chairman; the report was discussed informally later in the evening.

The Chairman, Mr. G. H. Gillam, then introduced Mr. J. P. McBreen and invited him to read his paper 'Some considerations in the application of power rectifiers and convertors'. A short review of the paper appeared in the May 1960 *Journal*, p. 298. During the discussion, opened by Mr. J. D. McColl, it was indicated that the choice between silicon and germanium rectifiers now depended almost entirely on economics. While motors rated at 9000 hp were operated from mercury-arc rectifiers, more development would be required before germanium or silicon equipment could be applied to the largest drives.

A vote of thanks to the author was proposed by Mr. H. S. Brown, who expressed the view that interest in rectifiers had increased greatly in the last few years and that there had been a need for a review of the limits of the subject. This had been well satisfied by Mr. McBreen's paper.

Sound broadcasting

At the meeting at Stoke on the 10th February 1961, the paper 'Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services' by Mr. F. Axon and Mr. O. H. Barron was introduced by Mr. E. A. Beaumont, who was followed by Mr. Barron. This paper was reviewed in the November 1960 *Journal*, p. 652.

The discussion was opened by Mr. A. Asbury, who commented on the wealth of foresight which had gone into this project. He was interested in the maintenance of the uniselectors which had made possibly 100000 operations to date, and was informed that these were enclosed in dust-tight cases and interfered with as little as possible. When a fault occurred, the unit was replaced and serviced later. It had not been necessary to replace any moving parts or any of the rhodium-tipped contacts.

The broadcasting was operated to a very tight schedule, and, as the programme change took place precisely at the quarter-hour, special arrangements had to be made for time signals. An interval of 20 seconds was allowed at the end of each programme for switching purposes, and the initial pips were accommodated in this interval.

Questions ranged over many aspects of the design and operation of the equipment. In proposing a vote of thanks, Mr. H. McCartney said it was a pleasure to receive such an

interesting and absorbing paper giving an over-all picture of the arrangements from the planning stage to final installation. He noted with interest that not only had duplicate power supplies been provided from the public supply system, but as many as three Diesel generators had been installed!

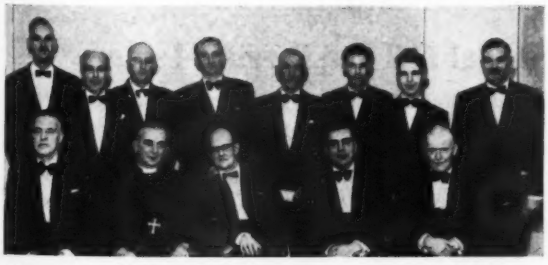
In their reply the authors explained that the three generators had been available in the various premises originally used and had been concentrated at Bush House in preference to buying one new set of adequate size.

The Annual Dinner and 'powers unseen'

The Annual Dinner, held at Stone on the 17th February 1961 and attended by about 130 members and guests, was again a memorable occasion. After the Loyal Toast, proposed by the Chairman, Mr. G. H. Gillam, the toast of The Institution was proposed by the Bishop of Stafford, the Right Rev. R. G. Clitherow, who, in lighter vein, said he still did not know why engineers should invite a Bishop to address them.

He suggested that the Church and engineers, especially electrical engineers, had much in common. Both dealt with a power unseen but capable of bringing a vast amount of good into life, and both were seeking to discover truth and use the fruits of discovery for the benefit of their fellows. We should have mutual toleration and understanding of each others' work and difficulties because, in all the majesty of this age of great and rapid discovery, everything finally depended on the spirit in man.

In responding to the toast, Mr. A. H. Mumford, a Vice-President, said that the Bishop had referred to the local manual telephone exchange. Although the target of a fully automatic system had not yet been reached, largely because of the rapid growth in the demand for telephones, it was anticipated that a number of electronically operated exchanges would be in operation shortly. He went on to mention the future use of satellites to provide transmission of telephone calls and television to any part of the world.



Guests at the North Staffordshire Sub-Centre Annual Dinner

seated (left to right): Brig. F. Jones, the Rt. Rev. R. G. Clitherow, Mr. G. H. Gillam, Mr. A. H. Mumford and Mr. J. F. Moxon

standing (left to right): Mr. W. T. Warnock, Mr. R. W. Palmer, Mr. A. Asbury, Dr. T. E. Calverley, Mr. H. McCartney, Mr. D. J. Andrews, Mr. R. E. Beadle, Mr. P. W. R. Gatliff

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The toast of the guests was proposed by Dr. T. E. Calverley, Vice-Chairman of the Sub-Centre. Mr. Mumford had referred, he said, to the problems of transmitting messages round the world and the necessity to use cables and repeater stations for this purpose. This seemed odd, since Mr. Mumford was a radio expert, but he understood it was largely due to interference from space. He thought Mr. Mumford and the Bishop might get together on this.

In responding to the toast, Mr. J. F. Moxon, a popular and notable solicitor in the Potteries area, thought the fare provided had been well above the level usually associated with an institution. His wife had thought there must be some mistake, but now he was not so sure. In commenting on the development of electronics he suggested that consideration should be given to the production of an electronic brain to replace the House of Commons, who he thought mainly spent their time in passing laws they did not understand and of which there were already far too many. L. G.

SCOTTISH CENTRE

Energy and electronics

Mr. W. L. Kidd, Chairman of the South-West Scotland Sub-Centre, reserved his Chairman's Address for the commencement of the second half of the session, and in Glasgow on the 18th January 1961 he gave an extremely interesting account of some of the problems that faced the South of Scotland Electricity Board as a result of the rapid growth of energy consumption; the use of extra-high voltage, production of reactive volt-amperes and general trends in cost for transmission and distribution apparatus were covered in a review which gave those present a valuable picture of probable conditions in the supply industry over the next decade.

Although a number of formal papers have been presented, this session has so far been notable for an increase in the number of informal papers delivered by local members. Mr. J. Henderson and Mr. C. L. C. Allan presented a joint paper, in both Edinburgh and Glasgow, on 'Energy resources in Scotland'. Prof. W. E. J. Farvis, recently appointed to the Chair of Electrical Engineering at the University of Edinburgh, spoke on 'The changing face of electronics' and surveyed developments from the time of Benjamin Franklin to the astonishing achievements of the present.

A picture of South Africa

On the 7th February 1961 Prof. M. G. Say spoke to the South-East Scotland Sub-Centre about his recent five-week visit to South Africa, where he had been invited to give the Bernard Price Memorial Lecture at a number of centres throughout the Union. As his subject was of a non-technical nature, ladies were invited to the meeting and a 'capacity' house resulted.

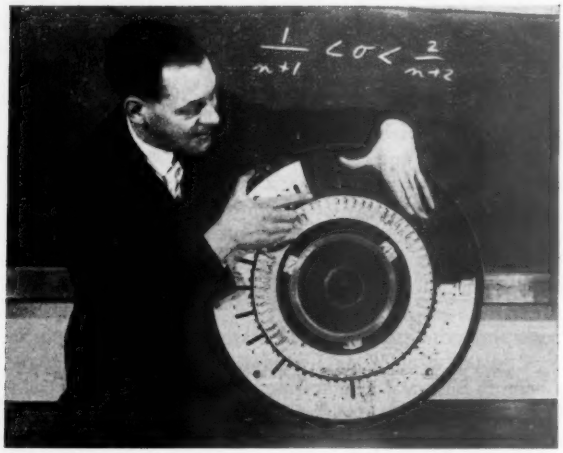
Although the talk included a brief 'travelogue' describing a visit to the National Park, the main part presented a lucid, concise and penetrating review of life and circumstances in South Africa at present, and most, if not all, of those present agreed that they had received a clearer picture of that country than could have been obtained by many hours of conventional reading. Colour slides, taken by the professor, were sometimes quite breathtaking, and in all cases showed precisely those scenes and events that one would wish to see.

In closing the meeting, the Chairman, Mr. I. S. Fraser, expressed the hope that Prof. Say would next year give the Sub-Centre the privilege of a similar talk on his forthcoming visits to Ghana and Russia. E. O. T.

WESTERN CENTRE

Choose your speed without brushes

On the 9th January 1961, the Centre had the pleasure of hearing an informal lecture, presented to them by Dr. E. R. Laithwaite, on the subject of brushless variable-speed induction motors. Such a motor was exhibited for operation by interested members at the conclusion of the lecture. The author, without any notes, lucidly presented what may well be a major break-through in variable speed with a.c. motors. He said that a commercial motor of 100 hp was in the course of construction and was designed for a speed range of 400–800 r.p.m.



Dr. Laithwaite describing the stator of the brushless variable-speed induction motor before the Western Centre

Dr. Laithwaite dealt with the development of cylindrical brushless motors using the 'pole-stretching principle'. The pole pitch of an induction motor was determined by the average phase-change from slot to slot of the current in the stator. Both the new machines were able to change this phase-increment-per-slot continuously so as to produce continuous change of the effective number of poles around the air-gap.

Because the motor was required to have non-integral pole numbers, a break had to be made in the magnetic circuit of the machine so that the flux threading the rotor could be destroyed and re-established in each revolution. Such machines had been termed 'short-stator machines'. The design of such motors was restricted in the choice of the operating speed range, and both the logmotor and the phase-mixer motor were essentially low-speed machines.

In the logmotor the stator slots each contained a single conductor which was fed from a special phase-shifting transformer. The latter had a primary winding in which successive coils decreased in size logarithmically, while the secondary consisted of single bars which fed the bars in the motor-stator slots. The arrangement was analogous to the C and D scales of a slide-rule.

In the phase-mixer motor, pole stretching was effected by mixing currents in the slots, one set of conductors being fed directly from the mains and the other from a conventional phase-shifting regulator, the number of turns in the two windings being suitably graded.

Production problems

Mr. G. Redfern, who opened the discussion, prefaced his remarks by stressing the production difficulties associated with the spherical motor and feared that the logmotor would equally give rise to trouble on the shop floor. However, he felt that the phase-shift control motor was definitely a reasonable manufacturing proposition and that once the speed range could be extended a bright future was assured for it. As an academic point of interest, he wondered whether the logarithmic sequence foretold the ultimate design of the logmotor or vice versa.

Mr. Redfern questioned the connections of the primary poles and suggested that a parallel connection would result in approximately equal flux per pole. He also raised the production point of killing the rotor flux and suggested that short-circuited windings were a more elegant answer than the short stator. He stressed the need for extension of the speed range.

Mr. P. Collins and Mr. E. J. Mathieson followed in the discussion and, after Dr. Laithwaite had suitably answered, the author was thanked by Mr. R. W. Steel. E. J. M.

EAST MIDLAND CENTRE

Annual Ball and Faraday Lecture

The Eighth Annual Ball, held on the 17th February 1961, was as successful as on previous occasions, despite some late cancellations owing to sickness.

Lt.-Col. W. E. Gill, the Chairman, introduced a new feature by proposing the toast of the ladies. Not to be outdone, the ladies found a champion in Mrs. R. L. Cannell, who gracefully responded.

'Transistors and all that'

The Faraday Lecture was given on both occasions (morning and evening) to capacity audiences in the largest assembly hall in the Centre on the 2nd March 1961. The morning Lecture was delivered to an audience of enthusiastic schoolchildren.

This was one occasion when the Lecturer needed no lengthy introduction before he plunged into his subject.

The extended applause was evidence enough to Lecturer and sponsors of the complete success of the 1961 Faraday Lecture. O. S. W.

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